Charlotte Area Local Watershed Plan

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Acronyms

BMP	best management practice
CMU	Charlotte-Mecklenburg Utilities
CSWS	Charlotte Storm Water Services
DHEC	Department of Health and Environmental Control
DLR	Division of Land Resources
DOT	Department of Transportation
DWQ	Division of Water Quality
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
FEMA	Federal Emergency Management Agency
GIS	geographic information system
HSPF	Hydrologic Simulation Program–FORTRAN
lbs	pounds
LID	low-impact development
LWP	Local Watershed Plan
MCSWE	Mecklenburg County Storm Water Engineering
MCWQ	Mecklenburg County Water Quality
μg/L	micrograms per liter
mg/L	milligrams per liter
MHAP	Mecklenburg Habitat Assessment Protocol
MNGWMD	Metro North Georgia Water Management District
NCDENR	North Carolina Department of Environment and Natural Resources
NCIBI	North Carolina Index of Biotic Integrity
NCWRP	North Carolina Wetlands Restoration Program
NPDES	National Pollutant Discharge Elimination System
NPS	non-point source
NWI	National Wetlands Inventory
RBP	rapid bioassessment protocol
SOER	State of the Environment Report
SWIM	Surface Water Improvement and Management
TM	technical memorandum
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WRC	Wildlife Resources Commission
WRP	Wetlands Restoration Program
WWTP	wastewater treatment plant

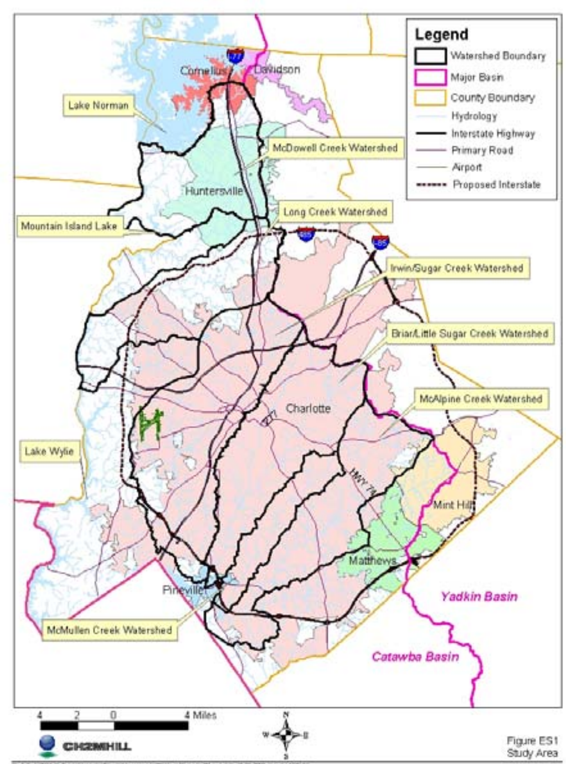
Executive Summary

Project Description

Local watershed plans (LWPs) provide a localized framework for strategically using various management tools to implement solutions for water quality and resource protection and improvement. This framework is established through projects and partnerships with local governments, which operate within local watershed boundaries. At the simplest level, these groups will work cooperatively to identify issues, to set priorities, to develop strategies, to secure funding, and to implement projects to protect and restore the watersheds within a community.

Project Stakeholders
Charlotte Storm Water Services (CSWS)
Charlotte-Mecklenburg Utilities (CMU)
Mecklenburg County Water Quality (MCWQ)
Mecklenburg County Storm Water Engineering (MCSWE)
North Carolina Wetlands Restoration Program (NCWRP)

LWPs strive to identify factors that contribute to water quality degradation within a watershed and to provide strategies to address non-point sources (NPS) of pollution. This approach allows for the determination of the sources and causes of water quality problems and also allows for the identification of areas on which to focus specific watershed preservation, enhancement, and improvement efforts. The next component of these watershed planning efforts is the identification of specific sites for best management practices (BMPs), wetland, stream, and streamside buffer restoration, which will aid in preserving or improving water quality in the focus areas.



Strategies also must be developed to address construction and post-construction runoff control, land use considerations, and other land development policies that may influence the future degradation of watersheds. Accordingly, the solutions identified in the LWPs include a comprehensive package of initiatives needed to successfully improve and protect water quality in the long term.

The Charlotte Area LWP includes six watersheds in the Catawba River Subbasin (Figure ES-1) and are as follows:

McDowell Creek	Briar/Little Sugar Creek
Long Creek	McMullen Creek
Irwin/Sugar Creek	McAlpine Creek

Existing Impacts

Local area data collected by various agencies were reviewed to assess the existing health conditions in the watersheds. The water quality results tend to confirm the conclusions of other studies in the Charlotte area. Sediment-related issues are significantly related to wet weather flows. Total phosphorus (TP) levels are elevated, and metals levels are somewhat elevated in the MCWQ storm and the Division of Water Quality (DWQ) ambient samples. This result is not uncommon for streams that are heavily influenced by urban stormwater. The biological data also show the general poor condition of the Charlotte area watersheds; however, many of the streams are characterized as only affected, or even as healthy, based on the habitat scores. There are a number of reasons for this, and the results should not be used to suggest that habitat modification is not a major contributor to poor biological conditions in the Charlotte area watersheds. Fecal coliform indicators of the suitability of waters for recreational activities are also elevated, but was not a focus of this study due to the development of total maximum daily loads (TMDLs) for fecal coliform throughout the study area.

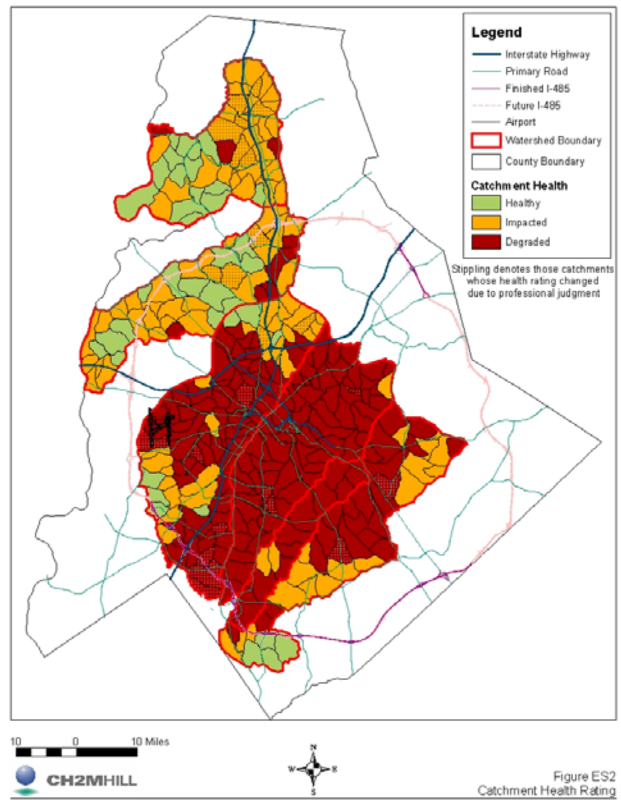


Figure ES2
Catchment Health Rating
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Impervious cover has the most significant effect on watershed health at the small watershed, or catchment level, according to the Center for Watershed Protection. The highly impervious nature of the Charlotte area watersheds is consistent with the poor ratings noted by these other indicators. Modeling results in the six watersheds also indicate significant sediment loads that are a likely cause of the poor health condition of many of the area streams. All of the sampling data and the impervious data were combined to create a graphic depiction of the health in each catchment (Figure ES-2).

Focus Area Evaluations

Because the existing degradation of the six watersheds is widespread, six areas within the watersheds were selected on which to focus efforts and to restore and/or protect water quality. Four restoration/ enhancement and two preservation focus areas were selected from a

Final Focus Areas

Restoration/Enhancement

Long at I-77 – Rapid Development
Stewart Creek – Dense Urban Development
Edwards Branch – Dense Urban Development
McAlpine Greenway – Sprawling Suburban Development

Preservation

Lawing School – Undeveloped, with potential for future development
Belmeade Drive – Undeveloped with potential for future development

candidate list of more than 30 focus areas. These focus areas represented groups of catchments within the watersheds and were characterized according to four different states of development. All of the focus areas are shown in Figure ES-3, and Table ES-1 summarizes the characteristics of each final focus area.

TABLE ES-1
Final Focus Areas
Charlotte Area Local Watershed Plan

Focus Area Name	Long Creek at I-77	Lawing School	Belmeade Drive	Stewart Creek	Edwards Branch	McAlpine Greenway
Focus Area Size (acres)	4488	282	2102	2030	1390	761
Predominant Catchment Health Rating	Impacted	Healthy	Healthy	Degraded	Degraded	Degraded
Average Percent Non-Forested Cover	54.1%	26%	36.9%	88.4%	87.1%	77.3%
Average Percent Buffer Non-Forested	26.3%	0%	7.5%	69.2%	91.8%	91.4%
Average Percent Floodplain Impervious	12.6%	0%	2.1%	21.9%	48.2%	11.5%
Average Water Quality (Pollutant Loading) lb/ac-yr						
TSS	708	413	463	942	845	560
TP	0.62	0.38	0.44	0.91	0.86	0.54
Zn	0.077	0.032	0.034	0.101	0.143	0.106
Preliminary Planned Activity	Restoration	Preservation	Preservation	Restoration	Restoration	Restoration

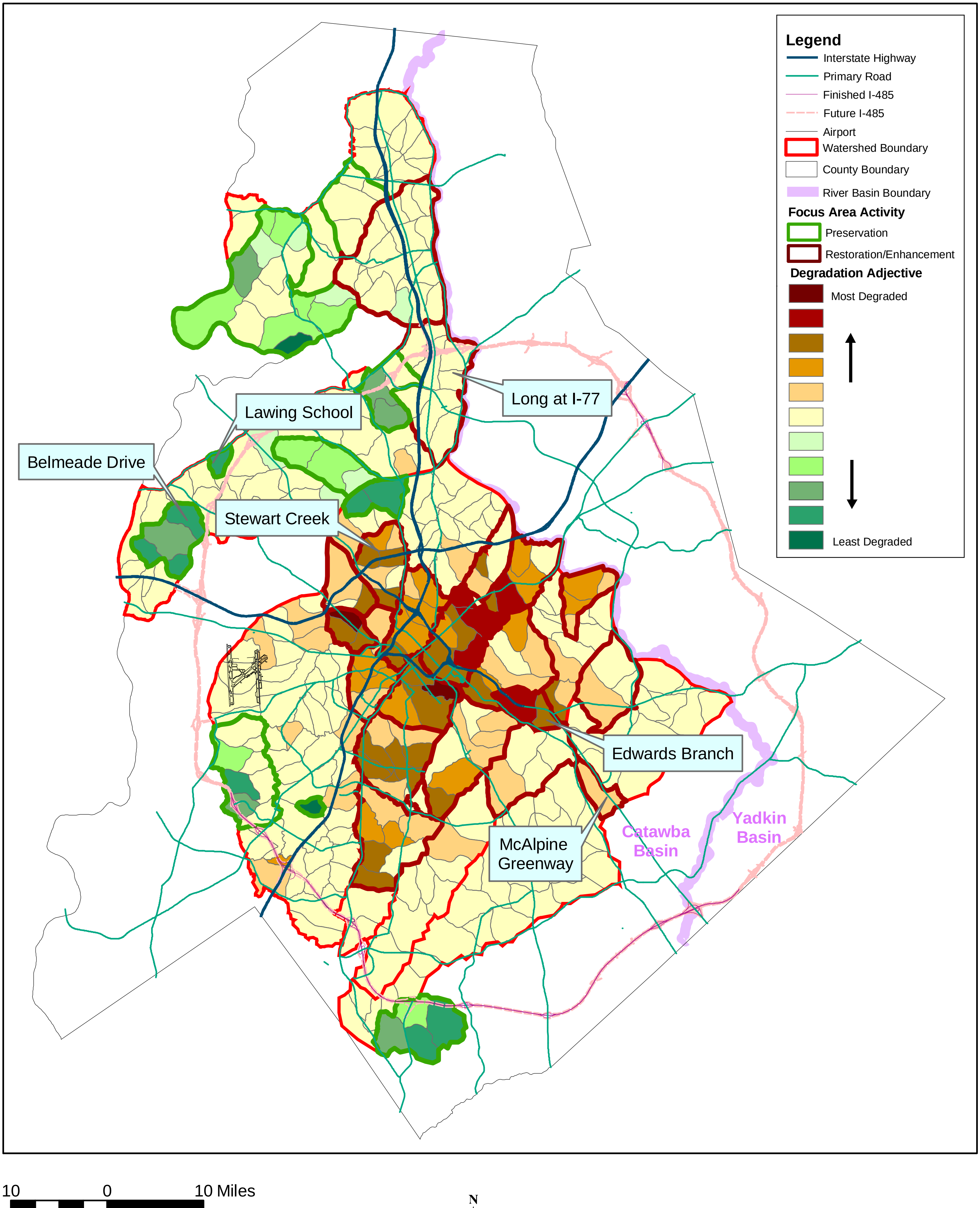

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Figure ES3
Focus Area Locations

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Stream reach and wetland sites were selected within the final focus areas through an in-office screening, then BMPs were selected to work in concert with the streams and/or wetlands to assist in restoring or protecting the focus area water quality. All of these sites were field assessed and verified. Once the data were analyzed from the field assessment, it was determined that some of the sites were not providing much additional benefit for the cost that was associated with the site. Figure ES-4 demonstrates how the benefits of the restoration sites were determined and subsequently eliminated from consideration. The purple circled sites were removed from the final recommended sites.

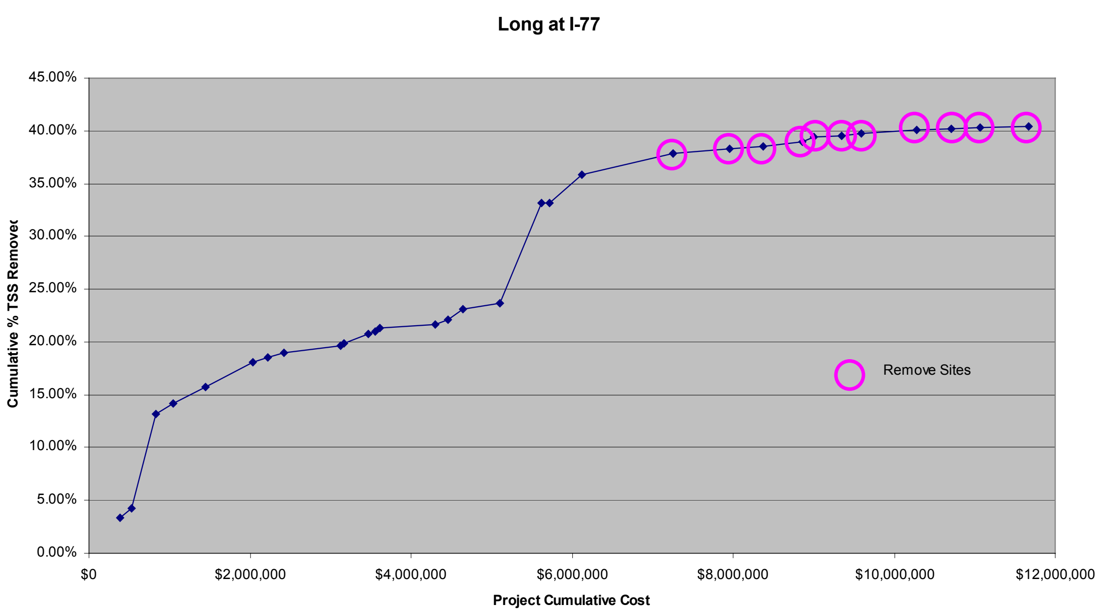

Figure ES-4
Project Cost vs. Cumulative TSS Removal

Each of the focus areas with the recommended sites are presented in Figures ES-5 through ES-10.

Table ES-2 summarizes the number of restoration sites, the estimated total suspended solids (TSS) removal, and the cost for implementation of the restoration activities. Preservation sites are not accounted for in this list because a TSS removal and a cost are not associated with these activities.

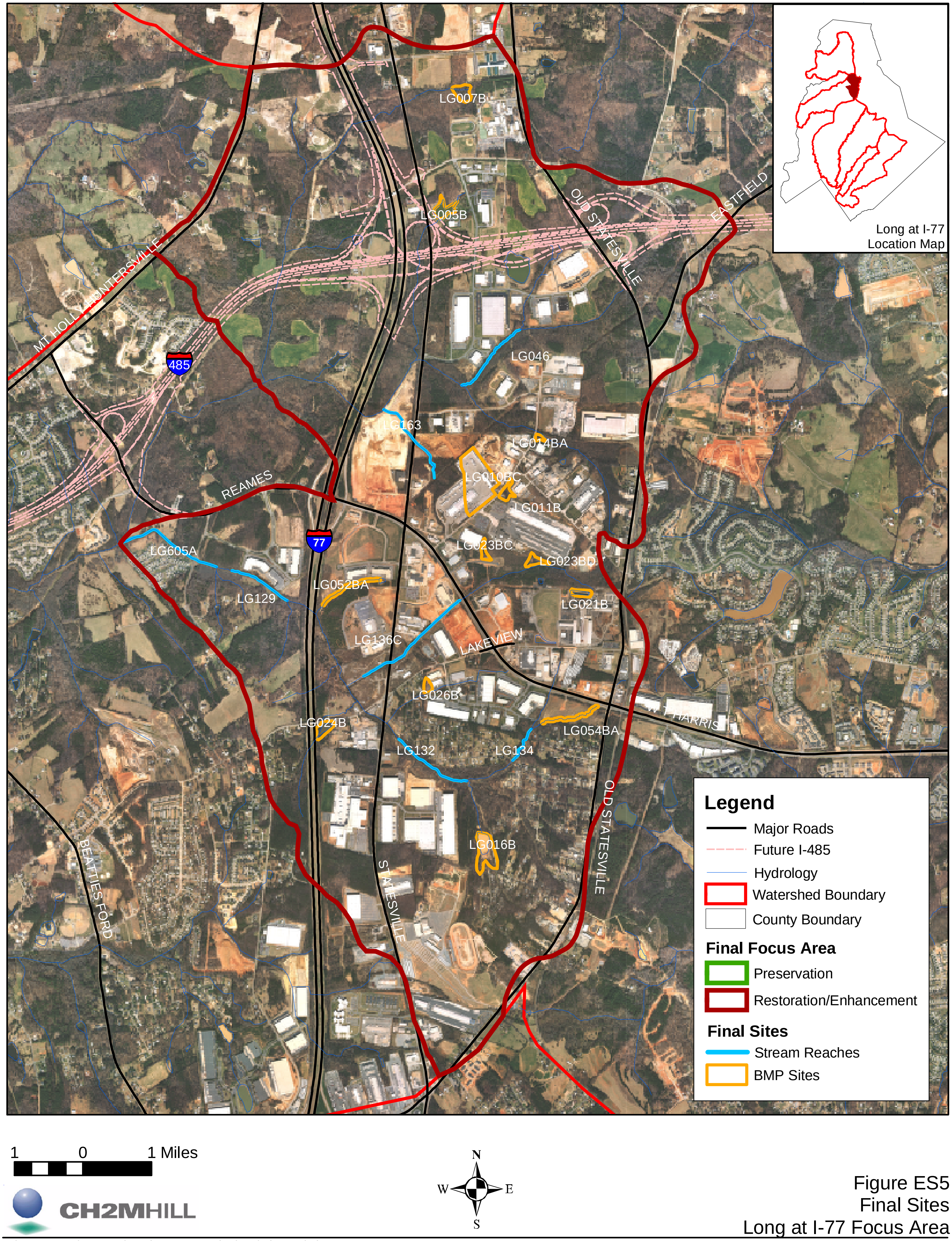

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Figure ES5
Final Sites
Long at I-77 Focus Area

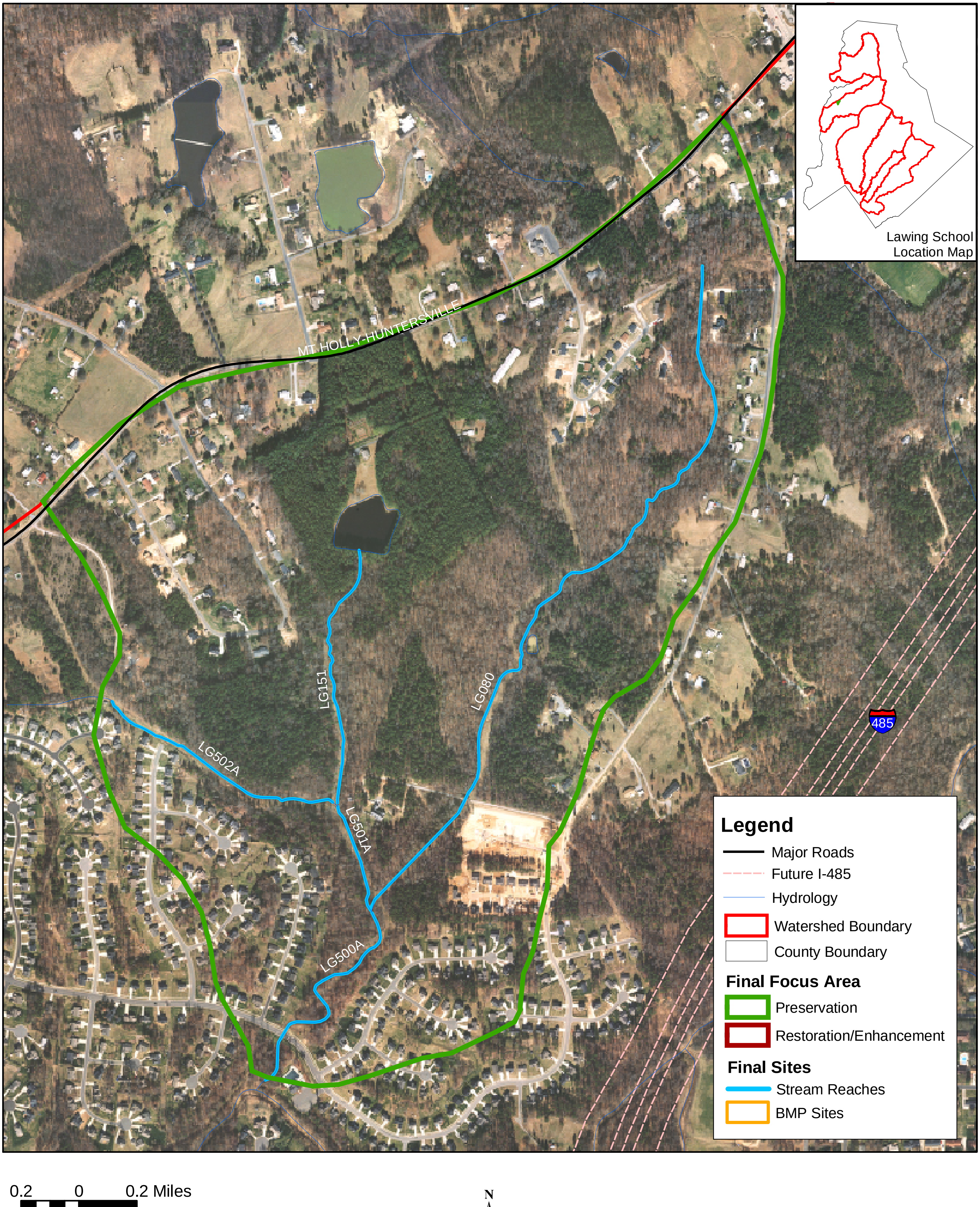

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Figure ES6
Final Sites
Lawing School Focus Area

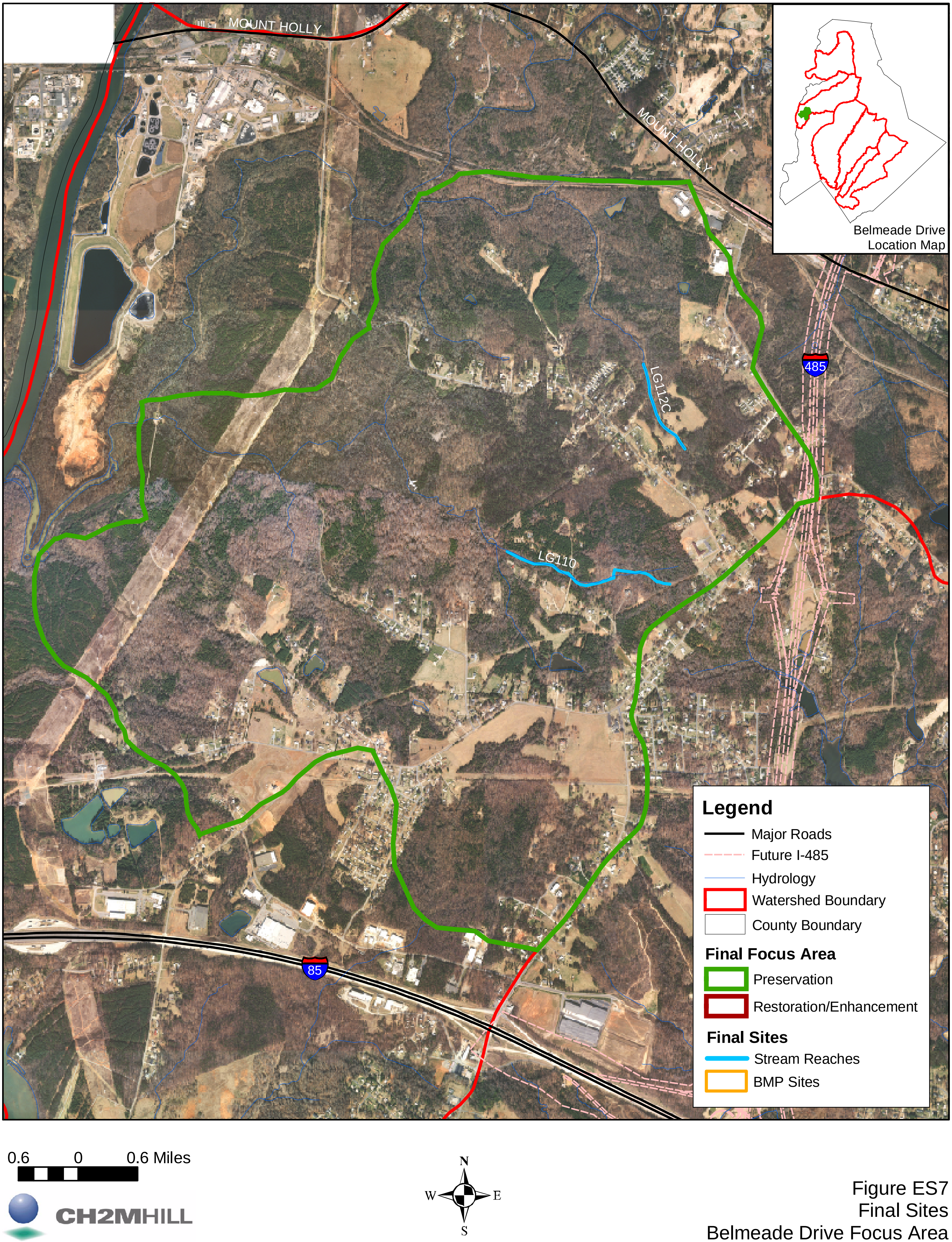

Figure ES7
Final Sites
Belmeade Drive Focus Area

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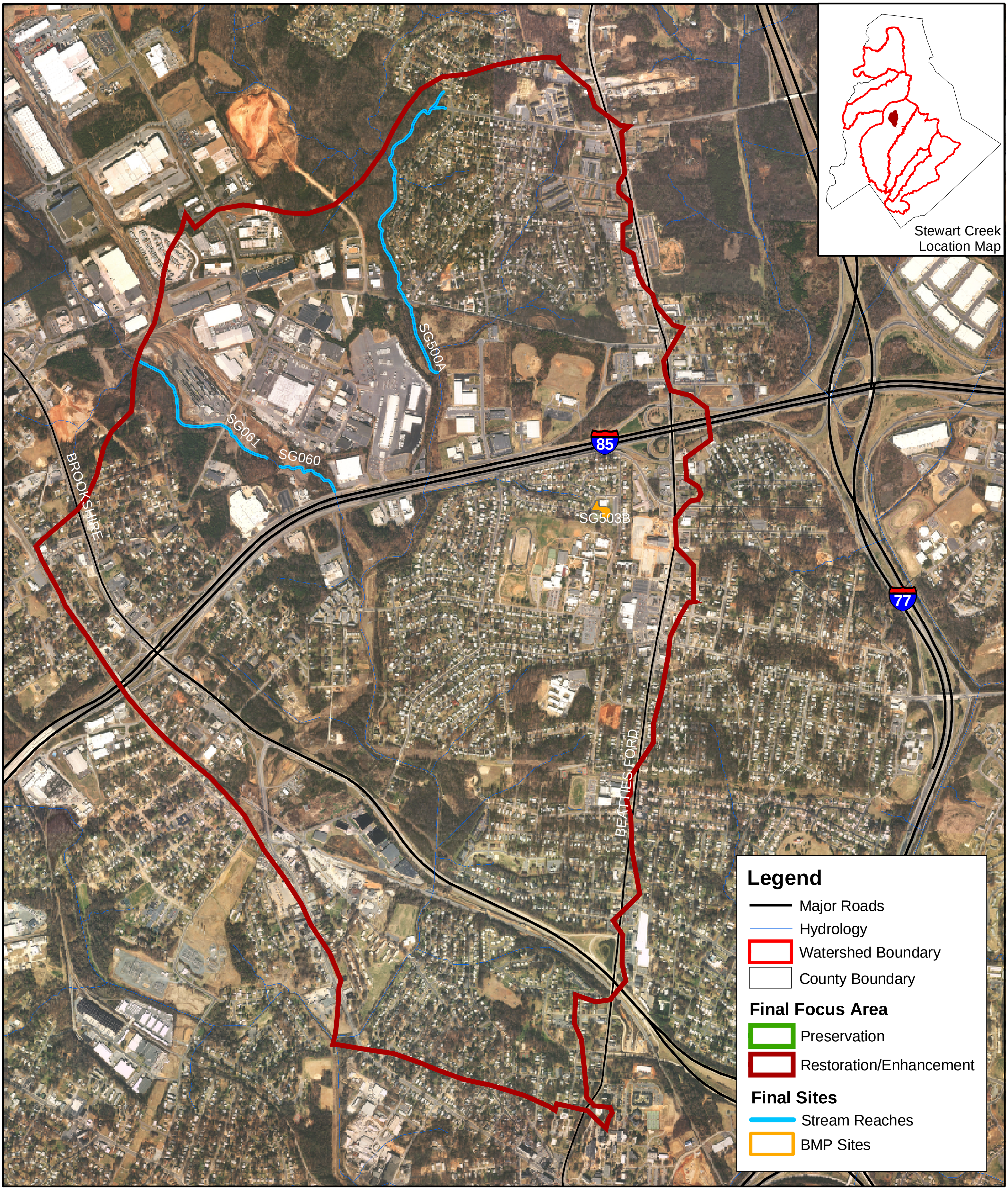

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Figure ES8
Final Sites
Stewart Creek Focus Area

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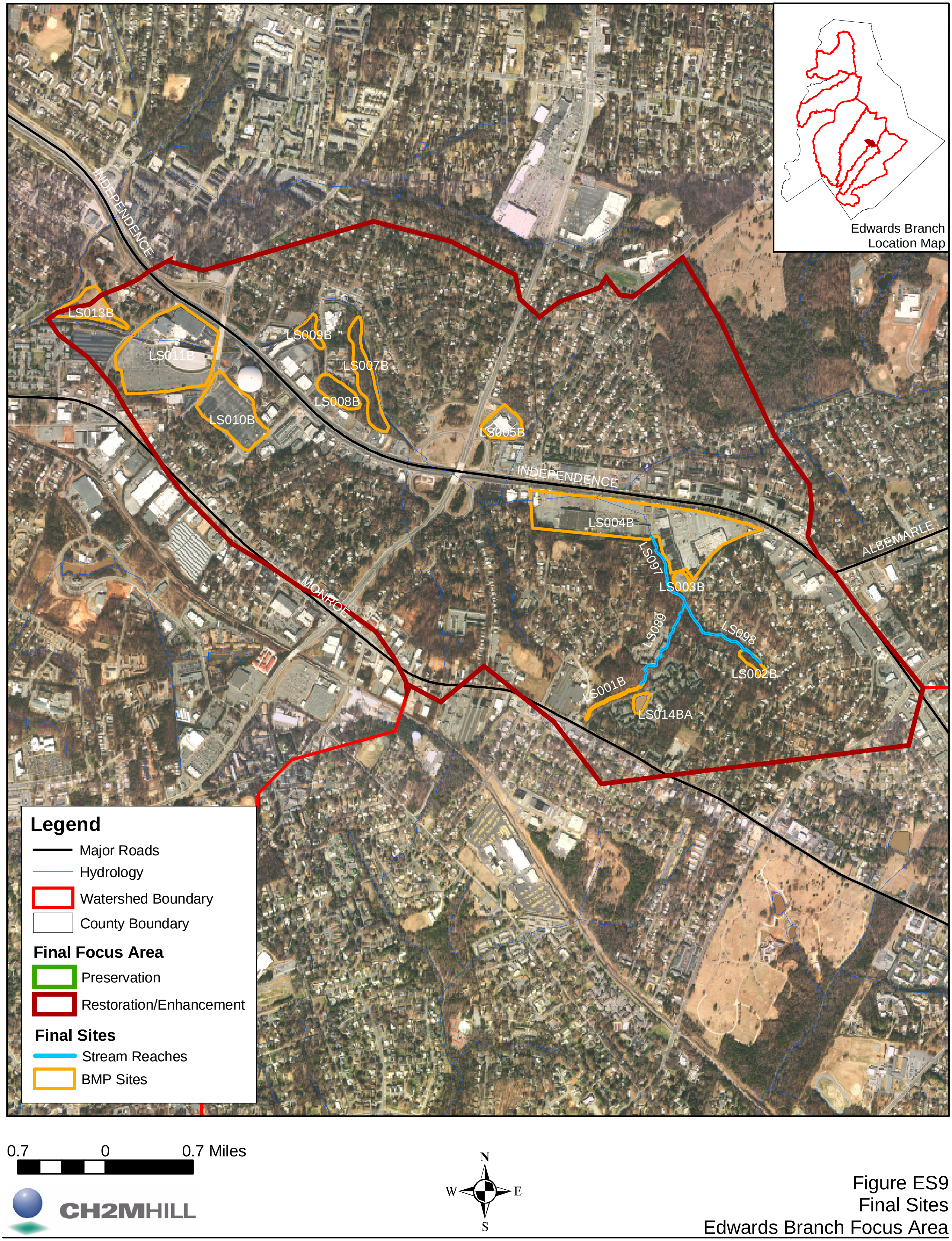

Figure ES9
Final Sites
Edwards Branch Focus Area

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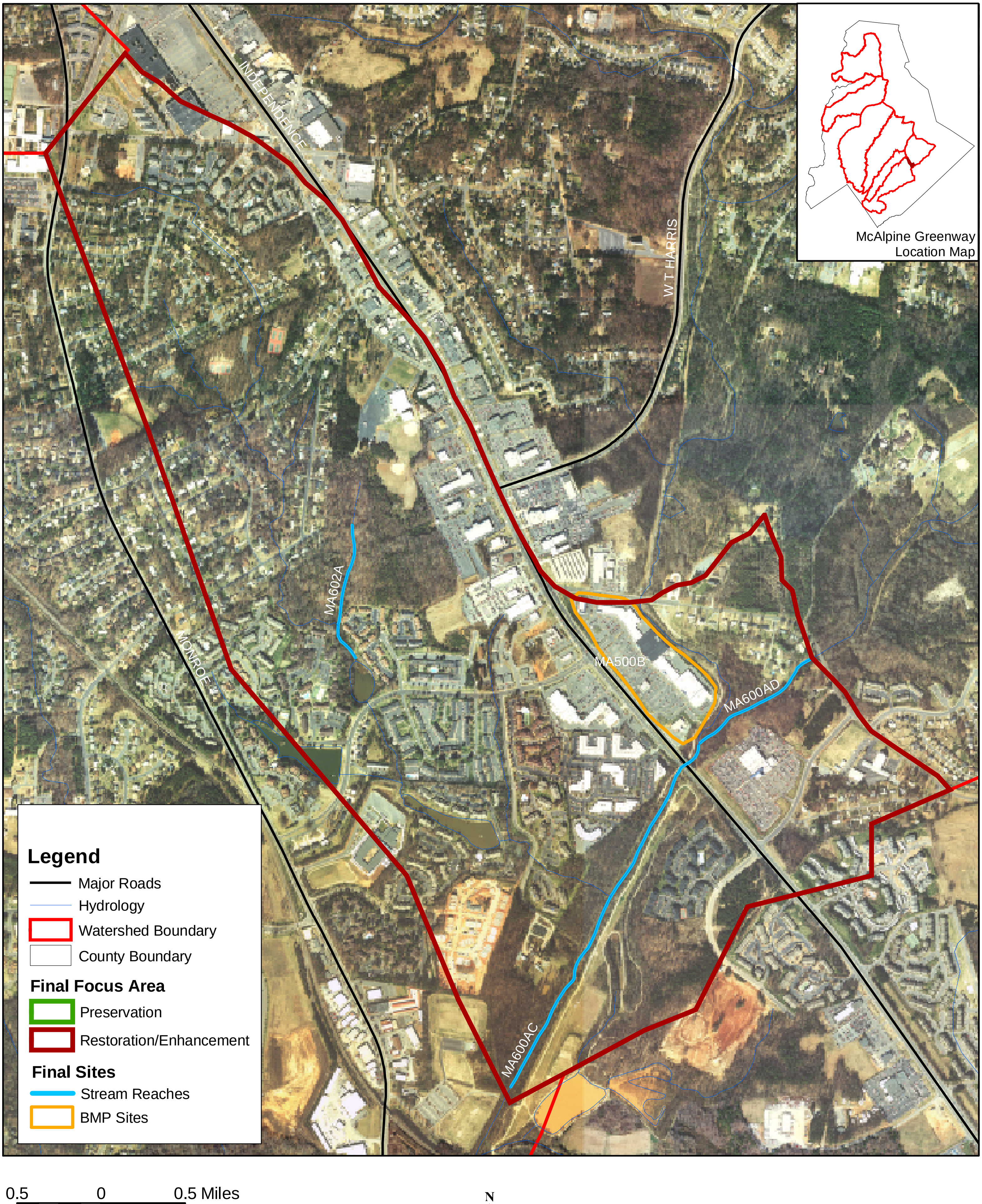

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Figure ES10
Final Sites
McAlpine Greenway Focus Area

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TABLE ES-2
Recommended Restoration Activities
Charlotte Area Local Watershed Plan

Focus Area Name	Watershed	Development Stage	# of Sites	Estimated TSS Removal	Cost
Long at I-77	Long Creek	Rapid	20	36%	$6,126,200
Lawing School	Long Creek	Undeveloped	5	35%	$1,878,700
Belmeade Drive	Long Creek	Undeveloped	2	35%	$945,500
Stewart Creek	Irwin/Sugar Creek	Dense Urban	4	38%	$1,963,100
Edwards Branch	Briar/Little Sugar Creek	Dense Urban	15	65%	$5,423,500
McAlpine Greenway	McAlpine Creek	Sprawling Suburban	4	35%	$1,732,159

In addition to the restoration activities listed above, preservation and management activities were identified in two of the focus areas. Three preservation sites were identified in the Long at I-77 focus area, which had been identified as rapidly developing. The Belmeade Drive focus area was identified as undeveloped, and the field assessment confirmed good conditions remaining. Six stream reaches were identified for preservation. In addition, stream enhancements are recommended along one reach because of Duke Power easement maintenance, and along another reach because of online impoundments.

This same site selection and analysis process can be conducted in the remaining 24 focus areas that were identified. These focus areas were identified as having indicators of degradation issues or the potential for preservation, and are classified in one of the four states of development. Due to the limitations of this project, not all focus areas could be assessed; however, this project has provided a foundation for future work. Similar approaches can be selected within these focus areas once this next level of priority can be funded.

Mitigation Potential

The recommendations for each focus area's specific management activities were based on the ability for these activities to be implemented and to improve water quality. However, the activities also are eligible to receive mitigation credit to offset impacts to waters caused by other projects. The streams and wetlands were assessed for their mitigation potential based on existing criteria. In addition, the watershed approach was assessed based on methodology currently being developed to determine the mitigation potential of BMPs working in concert with traditional stream and wetland restoration activities.

The rationale for using a watershed approach for mitigation credit is based on a BMP being expected to have positive benefit to a certain length of its receiving waters. Typically, in a headwaters situation, a BMP is proposed to receive credit for the positive benefit it has on the receiving waters downstream to the next confluence and stream order change. In non-headwaters focus areas, the impact of BMPs that discharge into the larger streams is much lessened. In these cases, an evaluation was made to equate the non-headwaters watershed to a smaller, headwaters watershed in terms of drainage area per length of perennial stream. Once an "equivalent small watershed" was found, the amount of stream credit per acre of the equivalent small watershed is extrapolated to the larger, non-headwaters watershed. A similar framework for earning wetland credit for BMPs was suggested; however, an assessment of the potential credit was not conducted.

Table ES-3 summarizes the potential mitigation credit for the focus areas. There may be a high and low value presented for streams and wetlands since there is a range of ratios depending on the type of credit that could be agreed to by the assessing agency.

TABLE ES-3
Mitigation Potential
Charlotte Area Local Watershed Plan

Focus Area Name	Watershed Approach, LF	Streams, LF		Wetlands, ac	
		High Estimate	Low Estimate	High Estimate	Low Estimate
Long at I-77	17,560	16,638	15,423	2.91	0.73
Lawing School		9,394	9,394		
Belmeade Drive		14,797	10,038		
Stewart Creek	2,347	8,571	8,571		
Edwards Branch	8,693	3,686	3,686	7.16	0.75
McAlpine Greenway	210	6,500	6,500		
Total	**28,810**	**59,586**	**53,612**	**10.07**	**1.48**

Additional Controls and Monitoring Options

Additional Controls

The project area is experiencing significant impacts from sedimentation and habitat degradation. High levels of TSS correspond with these impacts. Nutrient levels also are elevated and may affect impoundments. High metals levels, typical of urban stormwater, also have been observed. In addition, biological and habitat monitoring shows significant impairment. Quite a few water quality programs are already in place to assist in protecting and restoring water quality.

Additionally, a pollutant loading assessment was made to assess NPSs and point sources under existing and future management scenarios and land uses. A target loading of 600 pounds (lbs)/acre-year for TSS was estimated as an initial target for the portions of the study area that are heavily developed and significantly impaired by sediment. The loading target for TP, absent the point sources, is between 0.3 and 0.5 lb/ac-yr. Currently, there is no apparent zinc impairment in any of the watersheds.

Management scenarios for the existing and predicted future pollutant load included the following: the projects recommended within the six focus areas, new development control, stream restoration, and retrofits. The results indicate that in some of the watersheds, future land use results in significant increases in pollutant loading. Minor reductions are seen at the watershed level when the focus area projects are incorporated. When new development controls are implemented, however, significant reductions occur with the predicted loads. Further reductions are noted when stream restoration is included.

On the basis of the assessment of existing water quality programs and assessment of future conditions, it is strongly recommended that the local governments implement the post-construction runoff control element from the new National Pollution Discharge Elimination System (NPDES) Phase II Stormwater program as soon as possible. The analysis shows that continued urban development of areas outside of the City, as well as redevelopment/infill within the City will greatly increase sediment and other pollutant loading. The sooner the post-construction controls requiring 85 percent TSS removal are required, the better the ability to manage sediment loading and stream impacts.

In addition, efforts must be continued by local agencies to minimize sediment impacts to stream through effective implement and enforcement of sediment and erosion control programs for construction activities. The increase in stormwater volume and peak flow rate associated with urbanization should also be addressed. Design techniques that minimize the increase in runoff from stormwater through infiltration, retention, and evapotranspiration from urban development should be used to the maximum extent practical.

Additional Monitoring Options

There is generally good coverage of the streams, and a wide variety of water resources data are available. These data enable the assessment of overall water quality within the study area; therefore, no changes are recommended for monitoring locations and frequency in the overall project area. However, additional monitoring will be needed to assess the effectiveness of the projects that are implemented in the focus areas, as well as for other BMPs and restoration projects that may be implemented throughout the County.

As mitigation projects are implemented, it will be important to measure success of the BMPs and restoration projects. Success must be shown by improvements in the natural function of the watershed. To address this aspect, water quality monitoring will be needed to evaluate the effectiveness of the BMPs, and biological monitoring near catchment outlets should be performed. The use of only two biological metrics may not be adequate to evaluate water quality in smaller catchment areas. Thus, the City and County should consider expanding their biological metrics and comparing the metrics to a nearby reference site for small watersheds.

Introduction

This Charlotte Area local watershed plan (LWP) was developed for the North Carolina Wetlands Restoration Program (WRP) in conjunction with local stakeholders. The LWP presents the results of four tasks, as well as additional investigation of two topics. The four prior tasks are listed below; the key features of each are presented in the Executive Summary:

- Task 1: Scoping of Watershed Assessment and Project Needs–Goals and Objectives, Data Collection, Subwatershed Delineation, Historical Context Review, and Indicators Establishment
- Task 2: Catchment Characterization and Project Site Selection
- Task 3:
  - 3a: Modeling Approach and Development Program
  - 3b: Development of the Long Creek Watershed Model and Modeling Results for Existing Conditions
- Task 4: Targeting of Management

A detailed technical memorandum (TM) has been prepared for each task and is included as an Appendix.

The purpose of Task 5, Develop Management Plan and Implementation Strategy, was to present a water quality improvement plan that identifies projects to address the water quality, stormwater, and habitat concerns in the Charlotte area while providing for preservation, enhancement, and restoration of stream and wetland resources. In addition, the plan should include recommendations for implementation of the identified projects, additional control requirements for new and re-development, and monitoring.

The TMs for Tasks 1 through 4 address details of the water quality, stormwater, and habitat concerns, as well as proposed activities in specific locations to address some of these concerns. The Executive Summary presents an overview of the results of these prior assessments; however, a more detailed description of the current conditions and issues is included here. An overview of the processes developed to determine the areas of concern and the subsequent recommended activities is provided below. The following sections address the application of these processes to the remaining area in the watersheds, any additional controls that are recommended, and any changes that may be necessary in the current monitoring system.

Current Conditions and Issues

The greater Charlotte metropolitan area has enjoyed a healthy economy for most of this century, resulting in steady population growth and economic development. As shown in

Figure 1, the most drastic increases in population from 1990 to 2000 have occurred in the McDowell Creek and Long Creek watersheds, especially along the I-77 corridor in the northern part of the county. The majority of the McDowell watershed has had 100- to 250-percent growth, with an area to the west of the I-77 corridor showing 400- to 650-percent increases. Both sides of the I-77 corridor in Long Creek are showing 100- to 250-percent increases, with a small pocket to the southeast in the 250- to 400-percent range. Almost all of the rest of the watershed shows increases to 100 percent.

A population reduction has occurred in the areas surrounding Uptown Charlotte in the Irwin/Sugar Creek and Briar/Little Sugar Creek watersheds, while a residential portion of the center city has started to develop and has shown a 1- to 100-percent increase similar to the rest of the area in these two watersheds. The majority of the decreasing population area forms a wedge between the I-77 and I-85 interchange, with some area to the east of I-77. The uses in these two corridors are primarily industrial, distribution, and office parks. An area along the southwestern boundary of the Irwin/Sugar Creek watershed is showing an increase of 100 to 250 percent.

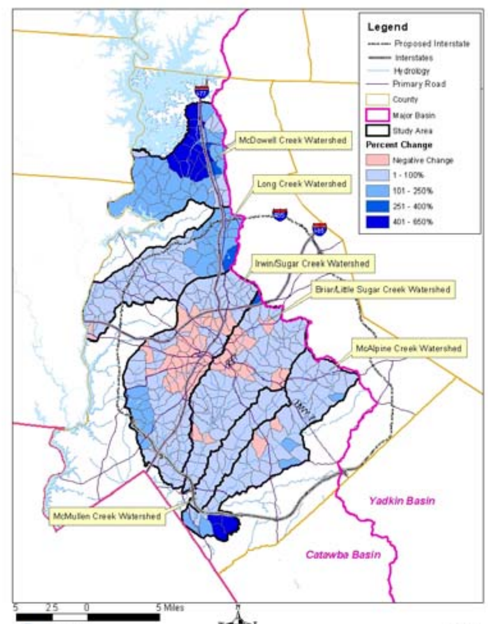

Figure 1
Percent Population Change from 1990 to 2000

The McMullen Creek and McAlpine Creek watersheds are showing a fairly consistent population increase up to 100 percent. A few catchments in the McAlpine Creek watershed are showing a decrease, and a few are showing a 100- to 250-percent increase. The greatest change is noted at the most southern portion of the watershed, with several catchments showing a 100- to 250-percent increase next to several catchments showing a 400- to 650-percent increase. This area coincides with the Ballantyne development.

From 1982 to 1992, the census count of farms and the acres of farmland showed a steady decline; however, a slight increase was shown from 1992 to 1997. The farm lands increased 4 percent from 27,901 acres to 29,015 acres, and the number of full-time farms rose from 132 to 133. Census data will not be available again until 2003; however, the Farm Services Agency indicated that there had been a significant decrease in both farms and farmlands over the past 5 years. Most of the producers had been in the northern portion of the county, with areas around Huntersville and Cornelius experiencing the greatest loss. This rapid growth in the northern and southern portions of the county and the loss of open space, resulting in greater impervious areas, have resulted in watershed health issues, as demonstrated in Figure ES-2. The impervious data used for the analysis were from 1998 land cover, and the increase in impervious area due to the development since 1998 would be expected to show even more degraded areas in the northern and southern portions of the county. Table 1 presents the data collected for each watershed and demonstrates some of the issues in each watershed.

TABLE 1
Detailed Watershed Description
Charlotte Area Local Watershed Plan

	McDowell Creek	Long Creek	Irwin/Sugar Creek	Briar/Little Sugar Creek	McMullen Creek	McAlpine Creek
% of Watershed in a Municipality	6% Cornelius 53% Huntersville 42% Mecklenburg County	33% Charlotte 2% Huntersville 65% Mecklenburg County	88% Charlotte 11% Mecklenburg County 1% Pineville	99% Charlotte 1% Pineville	96% Charlotte 3% Pineville	90% Charlotte 2% Matthews 6% Mecklenburg County 2% Mint Hill
1998 Predominant Land Cover (Based on Aerials)	46% Woods/Brush 41% Light Residential	49% Woods/Brush 34% Light Residential	32% Woods/Brush 26% Light Residential 17% Heavy Residential	51% Heavy Residential 15% Light Residential 10% Woods/Brush	54% Heavy Residential 21% Light Residential 15% Woods/ Brush	38% Heavy Residential 28% Woods/Brush 25% Light Residential
2015 Predominant Land Cover (Created Based on Zoning)	53% Heavy Residential 16% Woods/ Brush 12 % Light Residential	57% Heavy Residential 15% Heavy Industrial 10% Woods/ Brush	37% Heavy Residential 22% Heavy Industrial 14% Light Commercial 11% Heavy Commercial	67% Heavy Residential 10% Heavy Industrial	82% Heavy Residential 5% Institutional	80% Heavy Residential 5% Light Commercial 5% Woods/Brush
% Impervious (1998)	11%	14%	28%	40%	31%	24%
% Impervious (2015)	38%	44%	53%	47%	41%	42%
% Non-forested Cover (1998)	54%	51%	68%	90%	85%	72%
% of Length Buffer Zones Non-forested (1998)	47%	33%	45%	69%	50%	46%
% FEMA Floodplain Developed (1998)	45%	33%	40%	72%	45%	38%
Incidents of Flooding	4	0	5	14	5	23

TABLE 1
Detailed Watershed Description
Charlotte Area Local Watershed Plan

	McDowell Creek	Long Creek	Irwin/Sugar Creek	Briar/Little Sugar Creek	McMullen Creek	McAlpine Creek
Water Supply Watershed	81%	57%				
2000 Use Support: 303 (d) Part 1			23.7 miles of PS due to fecal. TMDL submitted	17.1 miles of PS due to fecal. TMDL submitted		20.4 miles of PS due to fecal. TMDL submitted
2000 Use Support: 303 (d) Part 4		15.3 miles PS due to turbidity	23.7 miles PS due to turbidity			20.4 miles PS due to turbidity
2000 Use Support: 303 (d) Part 5	9.8 miles PS with 5 miles listed with sediment as the cause		23.9 miles PS with 12.1 miles listed with sediment as the cause	22.4 miles PS, with 5.3 miles listed with sediment as the cause		20.4 miles PS with 15.7 miles listed with sediment as the cause
2002 Draft Use Support: 303 (d) Part 1 (now called Category 5)			Fecal TMDL approved 03/28/02. Now listed in Category 4a, formerly Part 3	Fecal TMDL approved 03/28/02. Now listed in Category 4a, formerly Part 3		Fecal TMDL approved 03/28/02. Now listed in Category 4a, formerly Part 3
2002 Draft Use Support: 303 (d) Part 4 (now called Category 4b)		No change from 2000	No change from 2000			No change from 2000
2002 Draft Use Support: 303 (d) Part 5 (now called Category 6)	No change from 2000		No change from 2000	No change from 2000		No change from 2000

Notes:
Heavy Residential: 0.25 to 0.50 acre lots
Light Residential: >0.50 acre lots
Incidents of Flooding: Spring 2001 Flood Hazard Mitigation & Bank Stabilization Study

The Process

A step-wise process was developed to characterize and assess the watersheds and to determine areas on which to focus restoration, enhancement, preservation, and additional watershed management activities. The phases of the process are as shown in Figure 2 and are as follows:

- Catchment Characterization–Assess and characterize catchments to determine areas with the greatest need for restoration, enhancement, preservation, and other management efforts.
- Focus Area Determination–Define focus areas so that projects can be grouped in a manner that makes their combined efforts toward pollutant removal, habitat improvement, etc., meaningful at a "watershed scale."
- Site Identification–Identify sites within the focus areas through in-office (geographic information system [GIS]-based) screening methods.
- Field Screening–Verify the office assessment and determine "best" stream reaches, wetland, and BMPs for restoration, enhancement, or preservation projects.
- Data Analysis–Finally, analyze the combination of in-office and field screening to determine the specific combinations of sites to be included in the final management recommendations.

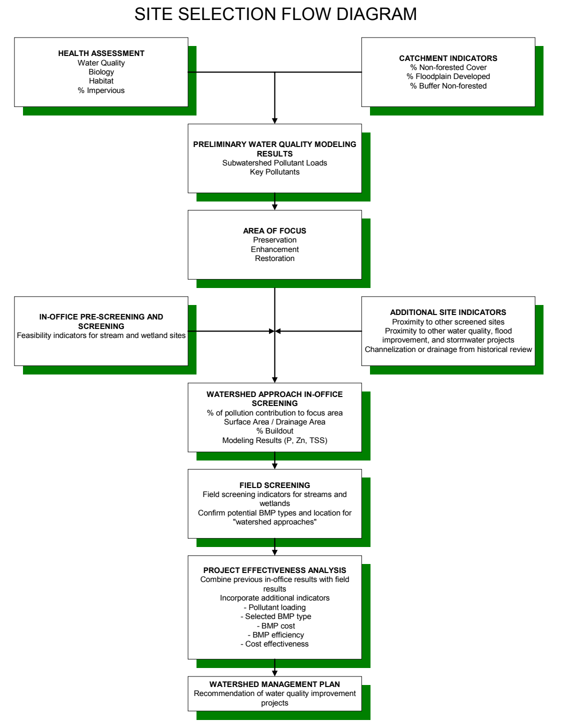

Figure 2
Process Flow Diagram

Project Goals and Data Review

A historical review of the streams in Mecklenburg County revealed some interesting information about the changes in land use over roughly the past 500 years. This review led to a hypothesis about how these changes in land use may have affected Mecklenburg County streams. Many records indicate that the Piedmont region, of which Mecklenburg County is a part, was primarily hardwood forests before settlement. There is, however, some evidence suggesting that prairies may have been present in significant amounts prior to English settlement. Also, the review suggests that Mecklenburg County streams may have been through three cycles of "clearing" adjacent to streams in the past 500 years. These factors have played a significant role in the evolution of the streams in the project area. Figure 3 depicts the possible channel evolution scenarios for many streams in the project area.

Understanding channel evolution helps lead to the selection of appropriate restoration sites and techniques. When proposing restoration, one always must decide to what condition a site should be restored. Commonly, this is perceived as returning an area to a "former" condition. Understanding channel evolution leads restoration efforts to be focused on restoring streams and wetlands to a "stable" condition, regardless of when they had been in that same stable condition before. Understanding channel evolution also helps determine what an area's state of "departure" from stability is, helping to determine just "how much" work needs to be done to "speed" the channel evolution process toward its ultimate conclusion–stability.

After reviewing historical data, it was time to determine the current conditions and to look toward the future. A determination needed to be made as to what was considered important and necessary to protect or restore water quality, as well as the criteria to meet the mitigation needs within the six watersheds. Indicators, a measurable feature that provides managerially and scientifically useful evidence of water and ecosystem quality or reliable evidence of trends in water quality and program effectiveness, were selected by the stakeholders to represent the goals of their agencies.

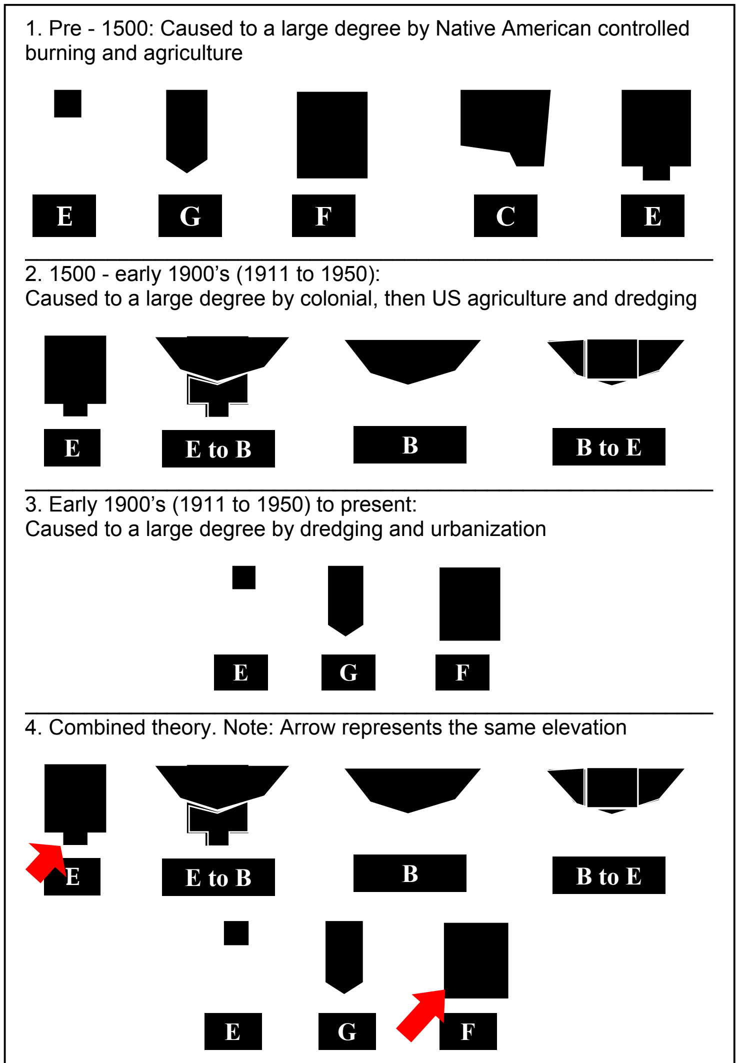

Figure 3
Channel Evolution Scenarios

Physical Condition Indicator Types
Water Quality
Habitat
Geomorphological
Biological
Vegetation
Hydrologic
Feasibility Indicator Types
Site Constraints
Socio-economic/Political
Programmatic/Regulatory

Two broad types of indicators were considered and selected–physical condition indicators and feasibility indicators. Physical condition indicators can be grouped into major classifications based on the type of information they relay about water and ecosystem quality and/or program effectiveness. These indicators provide information about the watershed integrity and were used in determining the catchments that need restoration, enhancement, or preservation. Feasibility indicators are more project specific and describe the ease of building a project. Indicators were selected for the phases of the process shown in Figure 2.

All of the details and supporting documentation regarding the available data, the historical review, and the indicator selection are included in TM 1, Appendix A.

Catchment Characterization, Focus Area Selection, and Project Site Selection

This task began with a detailed description of the study area and each of the six watersheds, based on the data collected for TM 1. The following information, some of which is presented in Table 1, was provided for each watershed:

Mecklenburg County has been identified by the state demographer as a high-growth area from 2000 through 2030, estimating a 90% growth rate over a 30 year period.

- Presence of municipalities
- Current and future land cover
- Imperviousness and non-forested cover
- Length of buffer zones
- Development within the Federal Emergency Management Agency (FEMA) floodplain
- Incidents of flooding
- Presence and type of National Wetlands Inventory (NWI) wetlands
- Predominant soils
- Use support

Once this general information was presented, the more detailed analysis began on the catchment level based on the indicators selected previously. Catchment-sized drainage areas were delineated for TM 1 to allow for characterization of the health or degradation conditions, as well as to provide guidance for selecting the specific type of project that would be appropriate (restoration versus enhancement versus preservation and other management practices) within that catchment.

A step-wise process was developed to assess the health of a catchment to represent the current conditions. This health rating resulted in a catchment being described as healthy, impacted, or degraded, and was based on water quality data, biological data, habitat data, and percent impervious information. These data were compiled in a database, and each catchment was evaluated based on the data available and the relationships among the multiple types of data. Figure 4 depicts the decision matrix for the determination of the overall health rating; the overall health ratings are shown in Figure ES-2.

Other catchment indicators also were assessed to assist in evaluating the needs for preservation, enhancement, or restoration and the likely success of these efforts. These indicators include non-forested cover, buffer non-forested, floodplain impervious, and water quality modeling results for total suspended solids (TSS), total phosphorus (TP), and zinc.

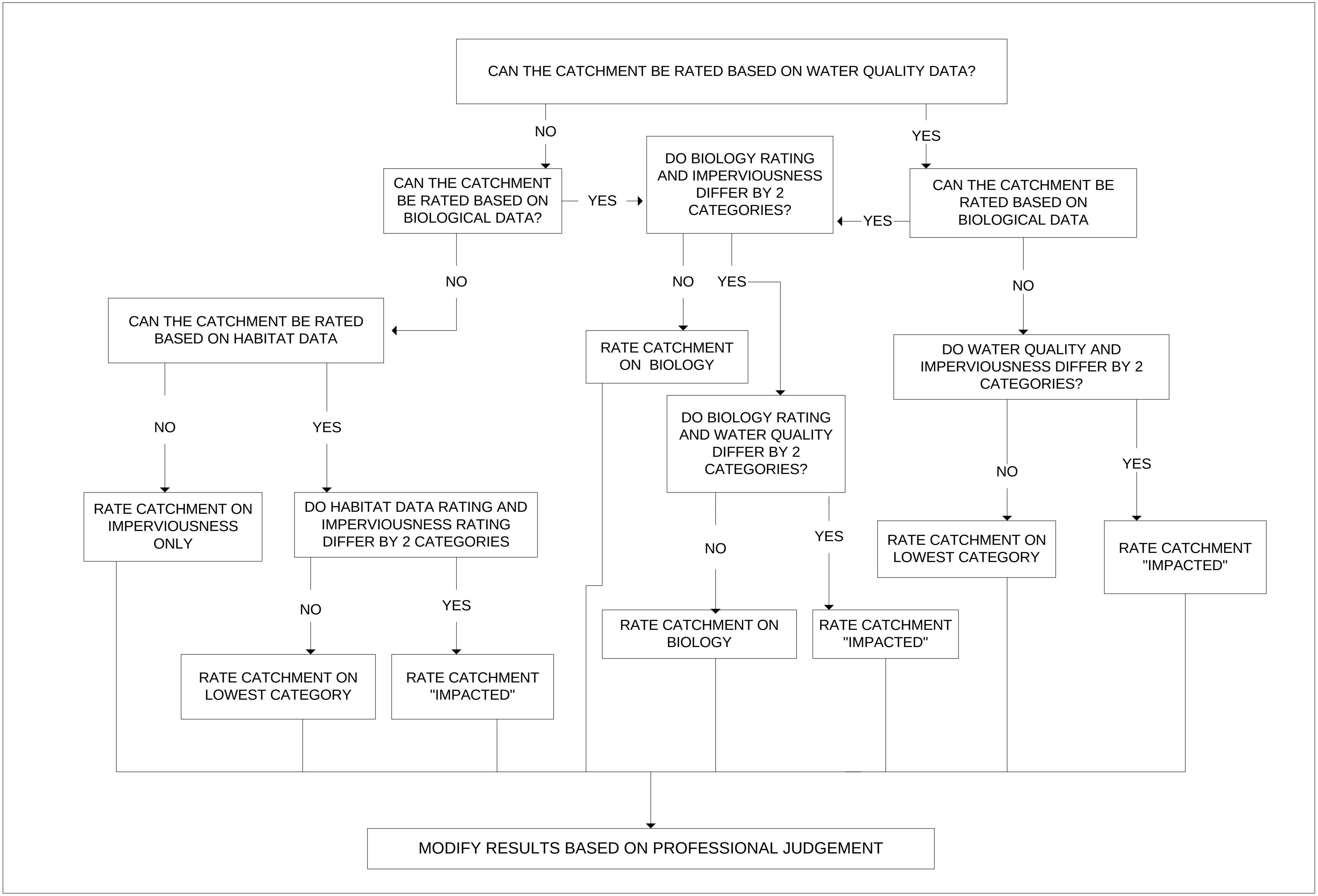

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Figure 4 Decision Matrix Catchment Health Characterization Flow Diagram

Once all of these data were compiled for each catchment, each of the indicators was assigned a score. The total score of each catchment was used to create a color-coded, GIS map so that clusters of catchments with like-characteristics (similar total scores) could be observed and subsequently assembled into a "focus area."

Figure ES-3 shows the color-coded GIS map with the focus area boundary drawn around each cluster of like-catchments. Initially, 30 focus areas were identified, 10 based on the least degradation (potential preservation activities) and 20 based on more degradation (potential restoration/enhancement activities). As indicated in the Executive Summary, the focus areas were narrowed down to four areas for restoration/enhancement and two areas for preservation.

Streams, wetlands, and various BMPs will work together within the focus areas, often in series, to remove pollutants and to adjust the hydrograph to offset the impact of impervious surfaces and other types of degradation in the drainage area. In conjunction with programmatic adjustments and other non-structural BMPs in the watersheds, the proposed activities at the sites will improve water quality and also provide mitigation credit for U.S. Department of Transportation (DOT) projects for the years 2004 and 2005.

Potential stream and wetland project sites initially were selected and then eliminated through an in-office pre-screening and a subsequently more detailed screening scoring process. These processes were based on the stakeholder-selected indicators. The goal of the in-office pre-screening and screening is to begin selecting potential project sites, including sites for preservation, enhancement, and restoration. This was an iterative process of eliminating sites that are not appropriate and then ranking and grouping the remaining sites based on feasibility indicators selected by the stakeholders.

Indicator Examples:
Number of Property Owners
Ease of Construction
Access
Utility Constraints
Building Constraints
Tree Removal
Educational Opportunity
Stream Reach Length
Wetland Area

Once the stream reaches and wetland sites were determined, the focus area was assessed to determine if portions of the drainage area were left unprotected from the effects of non-point source pollution. If so, then those areas were further inspected for potential locations for measures to protect water quality. Such measures included additional stream and/or wetland restoration sites, as well as other BMPs. In the event that the already identified stream and/or wetland sites left no unprotected subbasins, BMP locations were identified that would work in series with the stream and/or wetland sites to protect focus area water quality. The sites that were selected within each focus area are presented in Figures 5 through 10.

The detailed information regarding the catchment characterization, focus area selection, and project site selection is presented in TM 2 in Appendix B. The detailed modeling process and results are presented in TMs 3a and 3b in Appendix C.

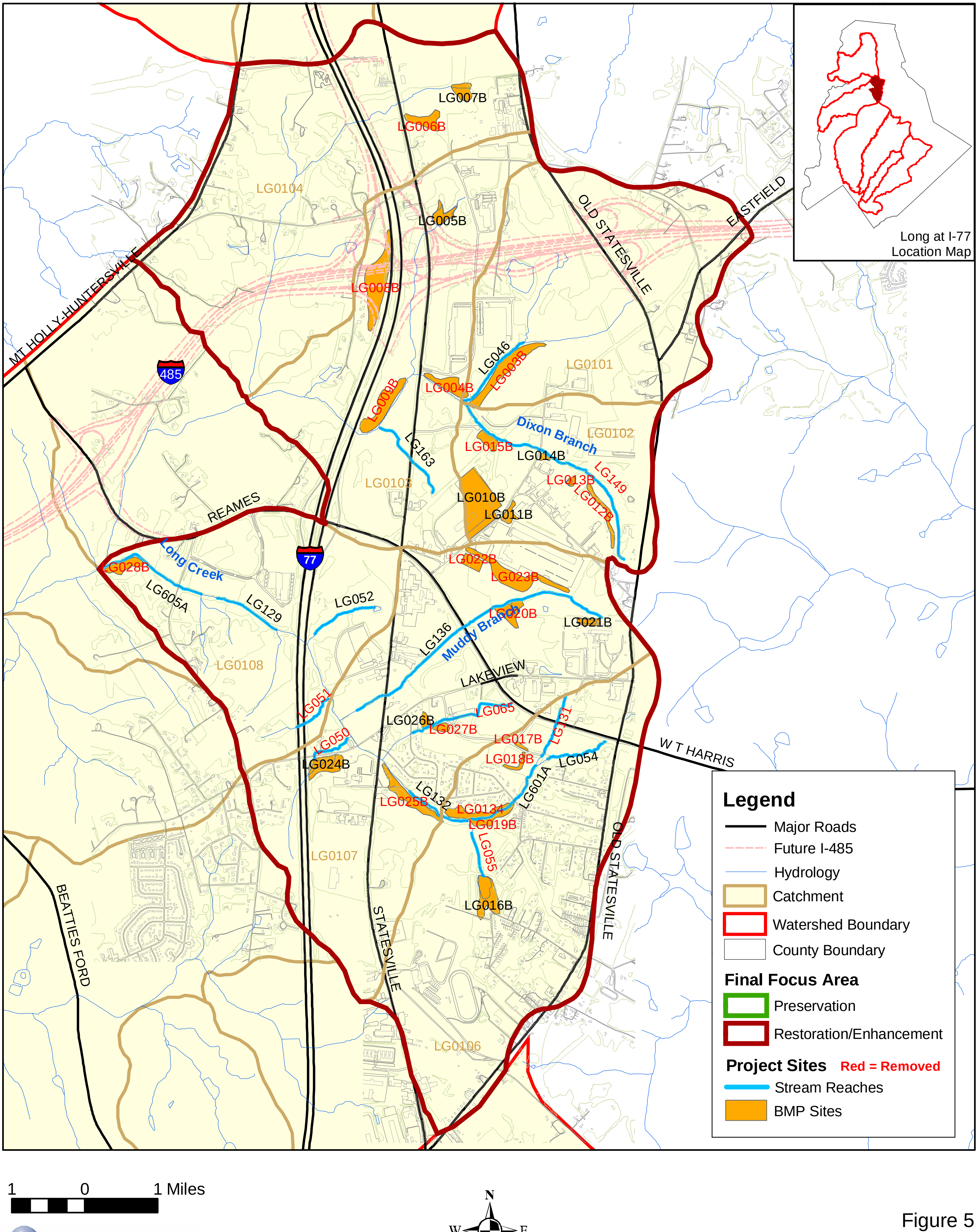

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Figure 5
All Field Sites
Long at I-77 Focus Area

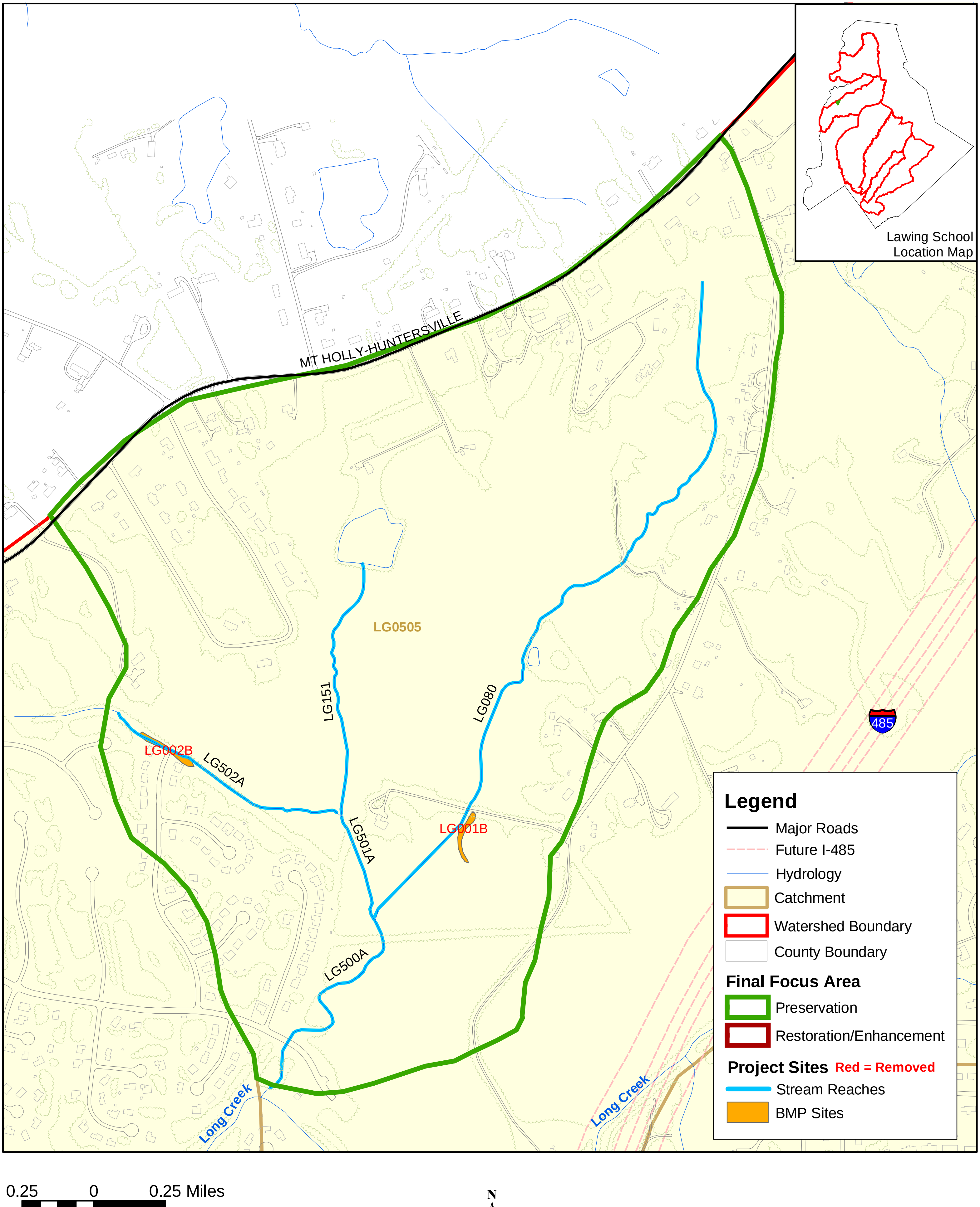

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Figure 6
All Field Sites
Lawing School Focus Area

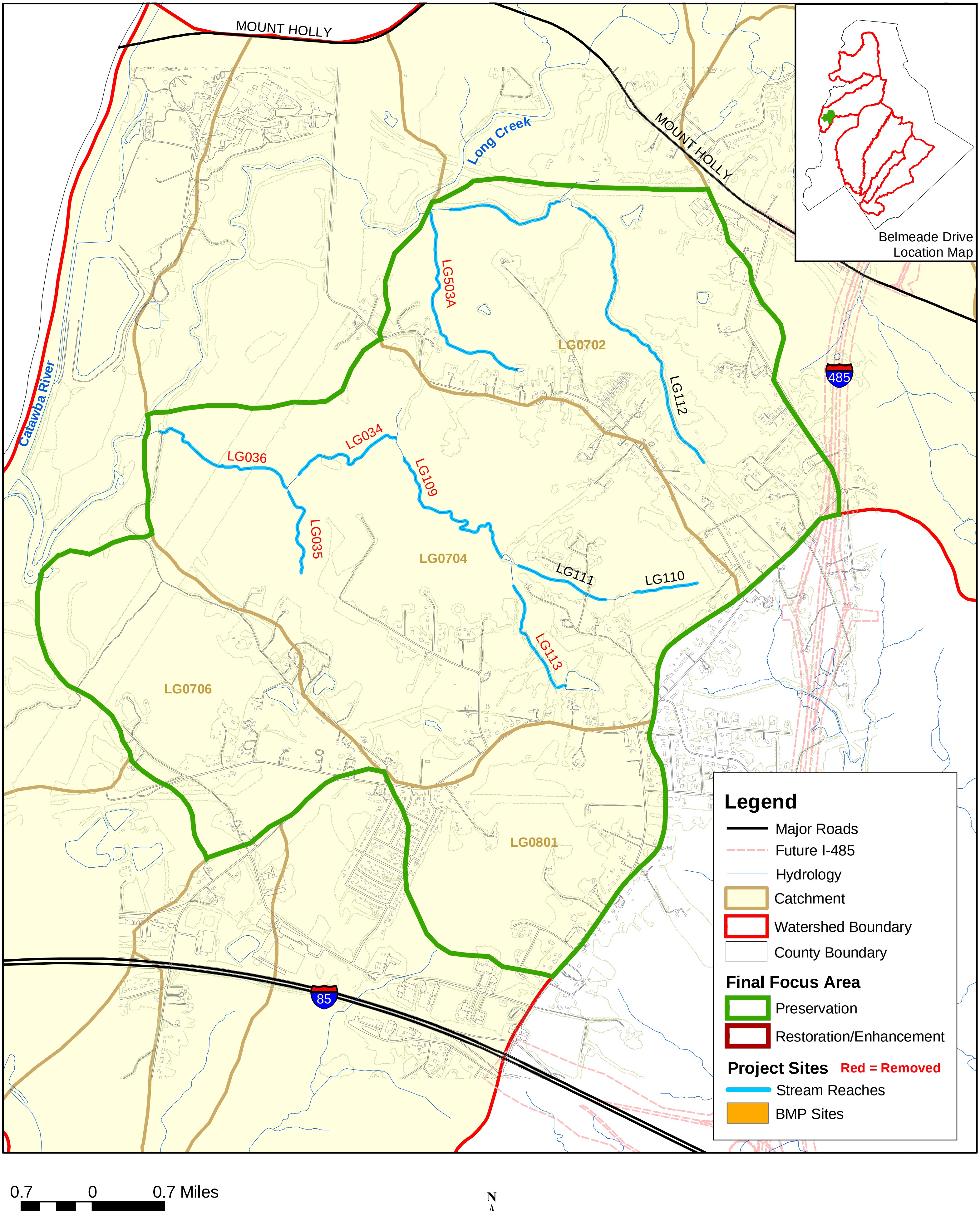

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Figure 7
All Field Sites
Belmeade Drive Focus Area

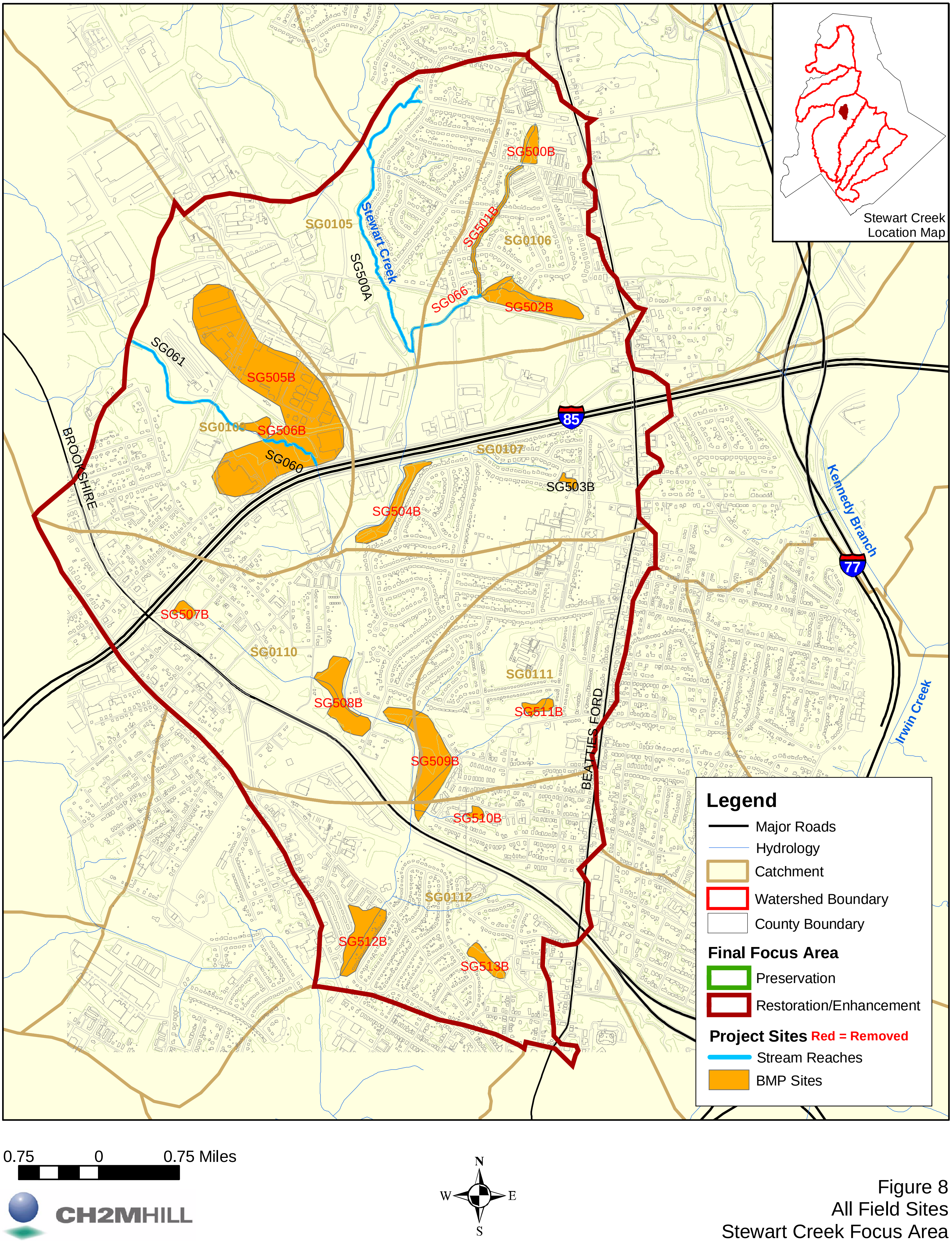

Figure 8
All Field Sites
Stewart Creek Focus Area

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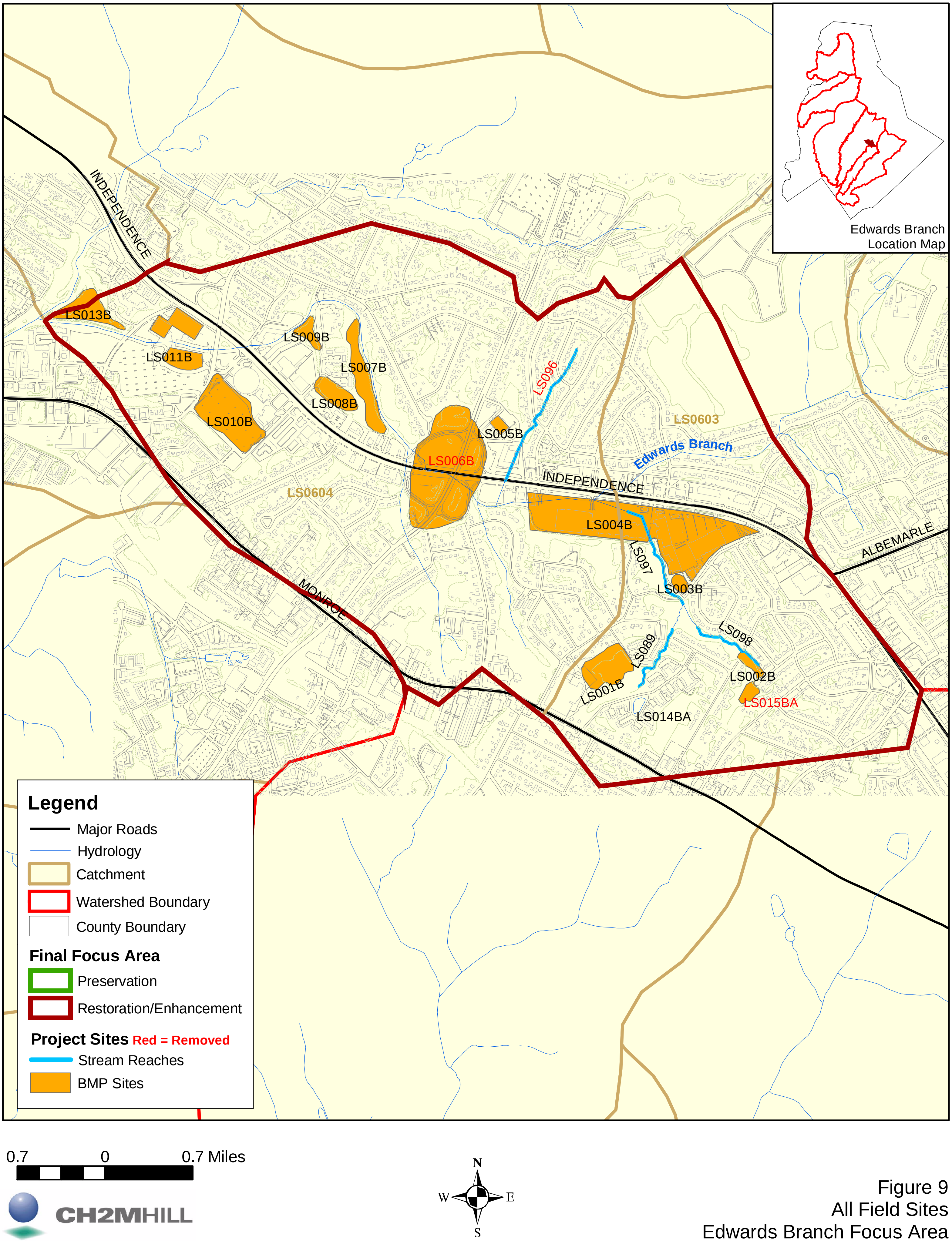

Figure 9
All Field Sites
Edwards Branch Focus Area

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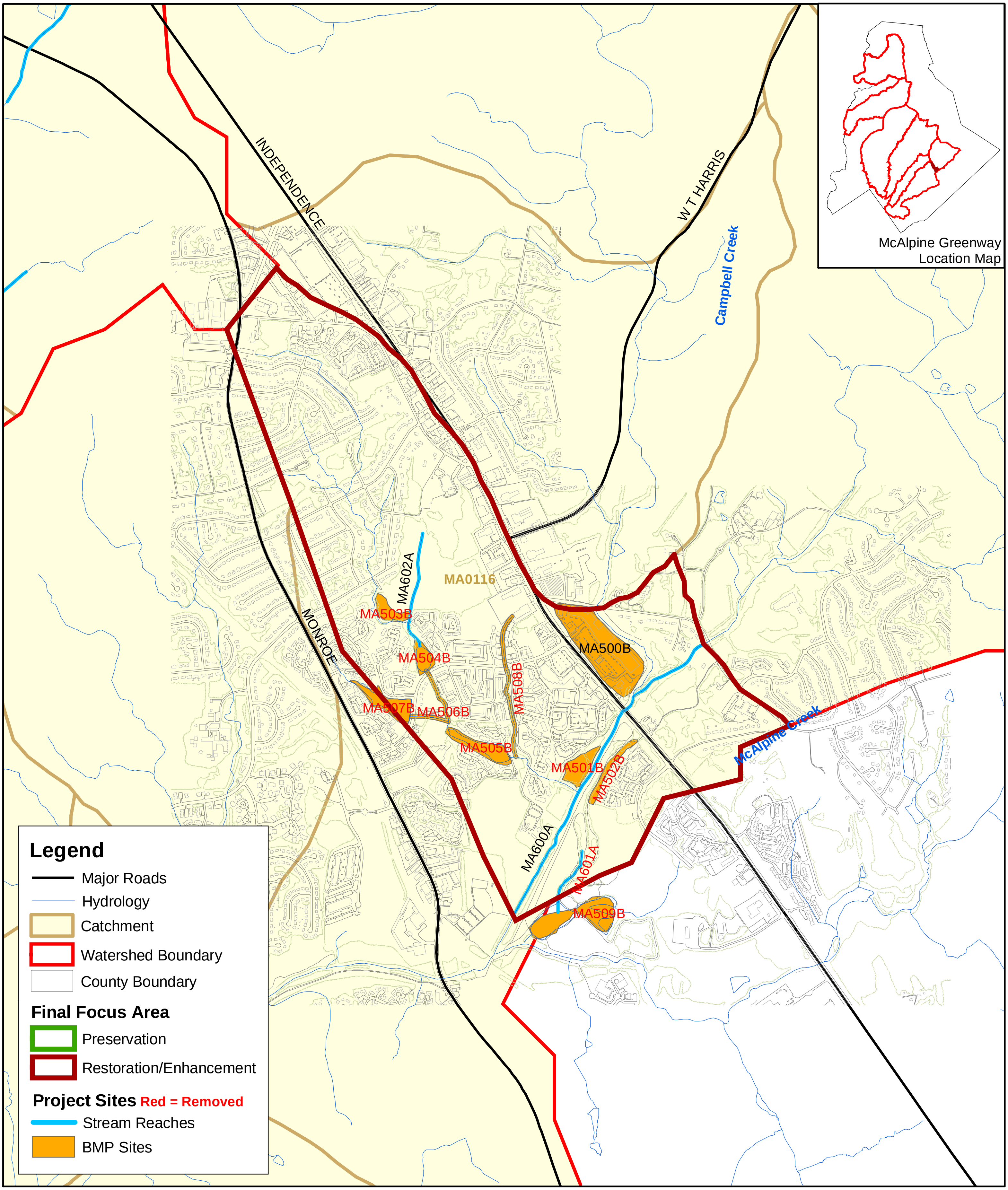

0.8 0 0.8 Miles

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W E
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Figure 10
All Field Sites
McAlpine Greenway Focus Area

Field Screening and Data Analysis

Once all of the project sites were identified within the focus areas, each site was field assessed. This step was important because the selection at this point had been made in the office based on GIS data. Due to the rapid growth in several of the focus areas, the GIS data often did not reflect current conditions. In addition, some of the indicators selected by the stakeholders earlier in the process could only be assessed from data collected through site visits.

Field Only Indicators
Rosgen Level 1
MHAP
BEHI
Vegetation
Confirm Feasibility

The data from the field assessments were compiled and some sites were either dropped from further consideration based on land use changes at the proposed site or were moved from restoration/enhancement to preservation based on healthy indicators. The sites were then scored based on four major metrics, each with several indicators:

- Metric 1: Degradation
- Metric 2: Feasibility
- Metric 3: Location Effectiveness
- Metric 4: Cost-effectiveness

On the basis of the total score a site received for the combination of the four metrics, the sites were ranked within the focus area grouping. The TSS removal for each site was determined, and the sites were graphed in rank order using TSS removed and a planning level cost estimate for each site. A graph was created for each focus area to assist in determining if all of the sites were cost-effective. As indicated in Figure ES-4, some sites do not provide much additional benefit for the additional cost and were removed from consideration. Figures 11 through 15 present the graphs for the remaining five focus areas. The sites circled in purple were removed from consideration.

FIGURE 11
Lawing School Data Analysis

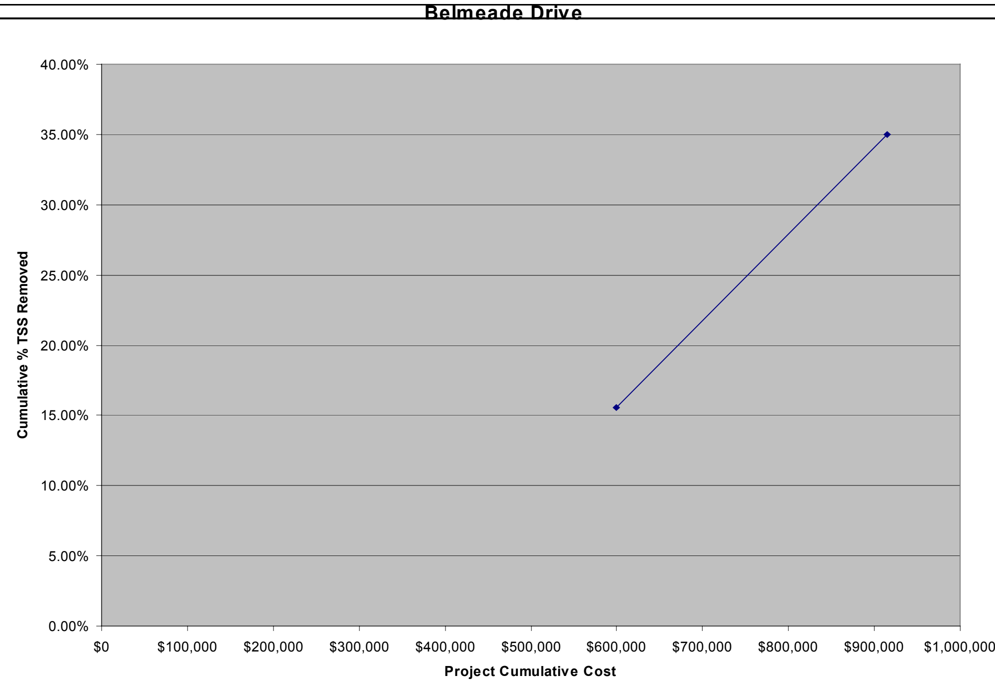

FIGURE 12
Belmeade Drive Data Analysis

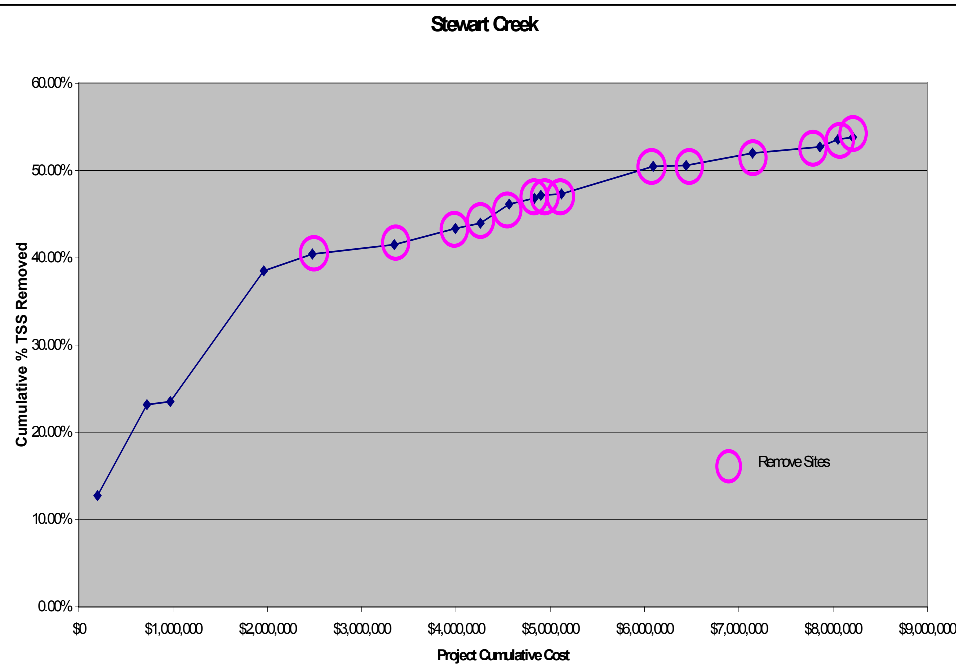

FIGURE 13
Stewart Creek Data Analysis

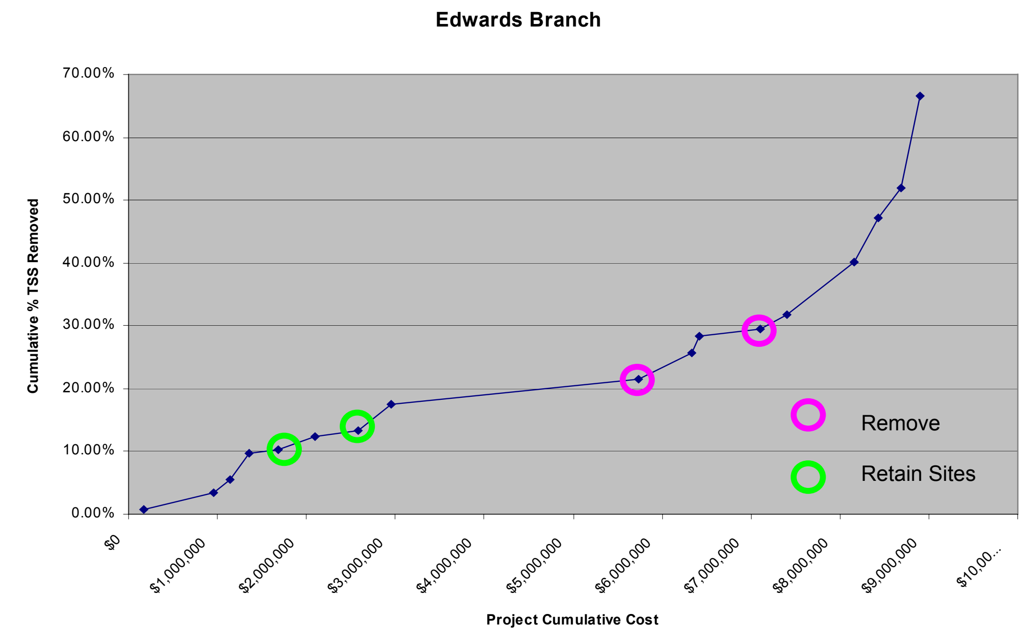

FIGURE 14
Edwards Branch Data Analysis

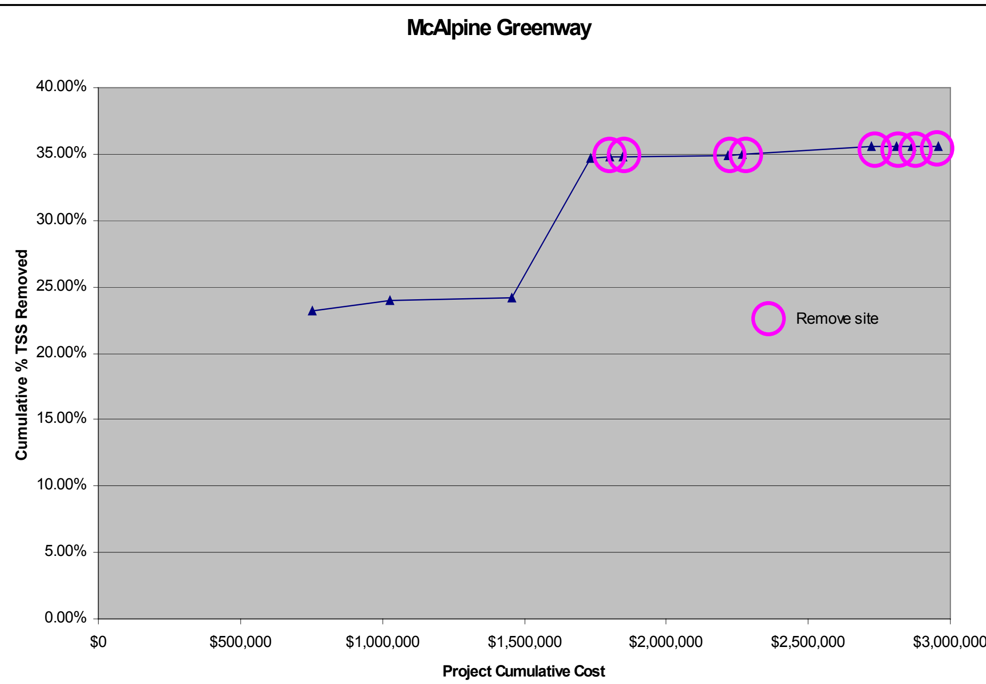

FIGURE 15
McAlpine Greenway Data Analysis

Table 2 demonstrates the pounds removed and the percent reduction of TSS, TP, and zinc for the focus areas based on the final recommended sites.

TABLE 2
Focus Area Final Site Selection Pollutant Removal
Charlotte Area Local Watershed Plan

Focus Area	TSS , lbs			TP, lbs			Zinc, lbs		
	Load w/o projects	Load w/ projects	% reduction	Load w/o projects	Load w/ projects	% reduction	Load w/o projects	Load w/ projects	% reduction
Long at I-77	3,135,736	1,872,265	40%	2,769.2	2100.5	24%	337.34	308.7	8%
Lawing School	116,508	44,843	62%	106.7	67.7	37%	9	9.0	0%
Belmeade Drive	939,787	899,716	4%	875.1	850.1	3%	69.06	69.2	0%
Stewart Creek	1,921,838	1,714,011	11%	1,850.1	1738.1	6%	206.98	206.8	0%
Edwards Branch	1,173,000	906,482	23%	1,190.2	1003.3	16%	198.72	182.4	8%
McAlpine Greenway	427,019	233,911	45%	372.3	281.9	24%	70.16	53.3	24%

Mitigation Potential

Once the final sites were determined, the mitigation potential was estimated. The April 2003 *Stream Mitigation Guidelines*, published by the U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (EPA), North Carolina Wildlife Resources Commission (WRC), and North Carolina Department of Environment and Natural Resources (NCDENR)–DWQ was used in determining how to account for stream activities in each focus area. The January 1997 *Compensatory Mitigation Guidance*, published by NCDENR–DWQ was used in determining how to account for wetland activities in each focus. The watershed approach estimates were developed based on discussions CH2M HILL currently is conducting with DWQ and USACE on another project.

A BMP is expected to have positive benefit to a certain length of its receiving waters. Typically, in a headwaters situation, a BMP is proposed to receive credit for the positive benefit it has on the receiving waters downstream to the next confluence and stream order change. In non-headwaters focus areas, the impact of BMPs that discharge into the larger streams is much lessened. In these cases, an evaluation was made to equate the non-headwaters watershed to a smaller, headwaters watershed in terms of drainage area per length of perennial stream. Once an “equivalent small watershed” was found, the amount of stream credit per acre of the equivalent small watershed is extrapolated to the larger, non-headwaters watershed. A similar framework for earning wetland credit for BMPs was suggested; however, an assessment of the potential credit was not conducted.

Table 3 summarizes the final recommendations and the mitigation potential for each site. All of the details and supporting documentation regarding the field assessment, data analysis, and mitigation potential determination are included in TM 4, Appendix D.

TABLE 3
Recommended Restoration, Preservation and Management Activities
Charlotte Area Local Watershed Plan

BMP ID	BMP Type	Rank[1]	Cumulative Percent TSS Load Removed	Cost	Maximum Mitigation Potential		
					Stream, LF	Wetland, ac	Watershed Approach, LF
			Long at I-77				
LG132	Stream Restoration - Rapidly Developing	1	3.37%	$390,935.20	1,955		
LG021B	Enhance Pond	2	4.19%	$139,399.24			*+LG023BD* = 6908
LG129	Stream Restoration - Rapidly Developing	3	13.21%	$300,000.00	1,500		
LG005B	Enhance Pond	4	14.16%	$214,702.01			149
LG016B	Enhance Pond	5	15.78%	$402,408.71			696
LG136C	Stream Restoration - Rapidly Developing	6	18.09%	$587,556.40	2,938		
LG024B	Enhance Pond	7	18.54%	$190,423.71			532
LG023BD	Wetland/Pond	8	18.93%	$200,775.87			*See LG021B*
LG011B	Bioretention	9	19.70%	$696,960.00			*+LG010B =* 2845.6
LG054BA	Filter Strip/Level Spreader	10	19.88%	$46,108.26			846
LG007B	Wetland Restoration	11	20.81%	$303,584.92		2.9	1266
LG014BA	Wetland/Pond	12	20.99%	$89,291.01			2243
LG052BA	Filter Strip/Level Spreader	13	21.30%	$46,413.18			898
LG010BC	Bioretention/StormCeptor	14	21.69%	$696,960.00			*See LG011B*
LG023BC	Wetland/Pond	15	22.09%	$149,198.72			552
LG601A	Stream Restoration - Rapidly Developing	16	23.09%	$190,527.60	953		
LG163	Stream Restoration - Rapidly Developing	17	23.67%	$452,092.60	2,260		
LG605A	Stream Restoration - Rapidly Developing	18	33.16%	$520,521.60	2,603		
LG026B	Enhance Wetland/Pond	19	33.17%	$108,381.96			624
LG046	Stream Restoration - Rapidly Developing	20	35.83%	$400,000.00	2,000		
LG055	Stream Preservation	P			604		
LG134	Stream Preservation	P			462		

TABLE 3
Recommended Restoration, Preservation and Management Activities
Charlotte Area Local Watershed Plan

					Maximum Mitigation Potential		
BMP ID	BMP Type	Rank[1]	Cumulative Percent TSS Load Removed	Cost	Stream, LF	Wetland, ac	Watershed Approach, LF
LG136D	Stream Preservation	P			1,365		
			Lawing School				
LG080	Stream Restoration - Rapidly Developing	1	6.38%	$889,667.00	4,448		
LG500A	Stream Restoration - Rapidly Developing	2	21.14%	$281,264.20	1,406		
LG151	Stream Restoration - Rapidly Developing	3	23.79%	$300,000.00	1,500		
LG501A	Stream Restoration - Rapidly Developing	4	30.83%	$124,298.20	621		
LG502A	Stream Restoration - Rapidly Developing	5	35.00%	$283,483.40	1417		
			Belmeade Drive				
LG110	Stream Restoration - Rapidly Developing	1	15.56%	$599,125.80	2,996		
LG112C	Stream Restoration - Rapidly Developing	2	35.00%	$316,326.00	1,582		
LG034	Stream Preservation	P			913		
LG035	Stream Preservation	P			627		
LG036	Stream Enhancement-DukeCMUD problems	M			1667		
LG104	Stream Preservation	P			926		
LG109	Stream Preservation	P			1,353		
LG112D	Stream Preservation	P			1,520		
LG113	Stream Enhancement-pond problems	M			1,841		
LG503A	Stream Preservation	P			1,374		
			Stewart Creek				
SG060	Stream Restoration	1	12.74%	$198,521.20	993		
SG061	Stream Restoration	2	23.19%	$524,028.00	2,620		
SG503B	Bioretention	3	23.54%	$248,814.72			2,347
SG500A	Stream Restoration	4	38.50%	$991,740.00	4,959		
			Edwards Branch				

TABLE 3
Recommended Restoration, Preservation and Management Activities
Charlotte Area Local Watershed Plan

BMP ID	BMP Type	Rank[1]	Cumulative Percent TSS Load Removed	Cost	Maximum Mitigation Potential		
					Stream, LF	Wetland, ac	Watershed Approach, LF
LS005B	Parking/Building Bioretention	1	0.70%	$174,240.00			Not Applicable
LS010B	Bioretention	2	3.49%	$780,720.00			*+LS011B =* 1097
LS009B	Wetland Restoration	3	5.52%	$190,057.15		1.5	*See LS007B*
LS011B	Parking/Building Bioretention	4	9.70%	$216,120.00			*See LS010B*
LS008B	Wetland/Pond	5	10.24%	$319,546.05			*See LS007B*
LS013B	Wetland Creation	6	12.38%	$412,533.70		3.0	1152
LS007B	Wetland Restoration	7	13.23%	$486,147.56		5.7	*+LS008B+ LS009B =* 3035
LS004B	StormCeptor	8	17.57%	$371,592.00			392
LS003B	Bioretention	10	25.75%	$597,991.68			670
LS014BA	Enhance Pond	11	28.38%	$88,427.81			*+LS001 =* 1320
LS001B	Bioretention	13	31.86%	$292,026.24			*See LS014BA*
LS002B	Bioretention	14	40.23%	$756,898.56			1030
LS098	Stream Restoration	15	47.09%	$266,336.40	1,332		
LS089	Stream Restoration	16	51.90%	$269,511.40	1,348		
LS097	Stream Restoration	17	66.56%	$201,306.60	1,007		
	McAlpine Greenway						
MA600AC	Stream Restoration - Rapidly Developing	1	23.17%	$754,722.80	3,774		
MA602A	Stream Restoration - Rapidly Developing	2	24.01%	$270,217.20	1,351		
MA500B	Bioretention/StormCeptor	3	24.22%	$432,240.00			210
MA600AD	Stream Restoration - Rapidly Developing	4	34.66%	$274,979.20	1,375		

Notes:
1 P = Preservation Site, not ranked
M = Management Activity, not ranked
Not Applicable = Receiving waters downstream of BMP immediately enters storm drain pipe, thus this BMP is not applicable for mitigation credit.

Process Application

During an earlier phase of this project, 30 focus areas within the six watersheds of this study area were identified. However, due to the limitations of this project, not all of the identified focus areas could be field-assessed for site selection. During this earlier phase, the focus areas were ranked either for potential restoration or for preservation activities based on the level of degradation. Nine focus areas were ranked in both the restoration and the preservation categories, leaving 12 that did not have the extreme indicators of degradation.

The focus areas also can be categorized based on the state of development, just as the final six focus areas were categorized: rapid development, undeveloped with potential for future development, dense urban development, and sprawling suburban development. Twelve focus areas of interest were categorized during the prior task, and the remaining focus areas have been assigned a development state.

Table 4 lists the focus areas and their rankings within the restoration/preservation category, as well as the development state. The Number 1 site for restoration means that it shows the most degradation and is in the greatest need of restoration. For the preservation group, Number 1 means that it has the least degradation and should be a top priority for preservation.

TABLE 4
Focus Area Ranking and Development State
Charlotte Area Local Watershed Plan

Focus Area Name	Ranking	Development State
	Restoration Ranked Focus Areas	
Freedom Dr	1	Dense Urban Development
NoDa	2	Dense Urban Development
Dilworth	3	Dense Urban Development
Edwards Branch[1]	4	Dense Urban Development
Hidden Valley	5	Dense Urban Development
Little Sugar/Hope Creeks	6	Dense Urban Development
Johnson C Smith	7	Dense Urban Development
Stewart Creek[1]	8	Dense Urban Development
Starmount/Huntingtowne Farm	9	Sprawling Suburban Development
	preservation Ranked Focus Areas	
Nations Ford	1	Dense Urban Development
Capps Hill Mine	2	Rapid Development

TABLE 4
Focus Area Ranking and Development State
Charlotte Area Local Watershed Plan

Focus Area Name	Ranking	Development State
Lawing School[1]	3	Undeveloped with the potential for future development
Belmeade Drive[1]	4	Undeveloped with the potential for future development
Ballantyne	5	Rapid Development
Gutter Branch	6	Rapid Development
Vance Road/New Mall	7	Rapid Development
Lower McDowell	8	Rapid Development
Eagle Lake	9	Rapid Development
Non-ranked Focus Areas		
Torrence Creek		Rapid Development
Long at I-77[1]		Rapid Development
Birkdale		Rapid Development
Hickory Grove		Rapid Development
Sharon Memorial Park		Sprawling Suburban Development
Sugaw Creek		Dense Urban Development
McAlpine Greenway[1]		Sprawling Suburban Development
Myers Park-Lower Briar Tribs		Dense Urban Development
Hoskins Park		Dense Urban Development
Central-Upper Briar Tribs		Dense Urban Development
The Plaza		Dense Urban Development
Wilmore/Revolution		Dense Urban Development

Note:
1 One of the final six focus areas

The final six focus areas assessed for site selection were not the top-ranked focus areas, but other issues were considered when selecting the final focus areas. At least one focus area was selected from each of the four development states. The selection and ranking of focus areas were based on GIS data, which can become dated in rapidly developing areas. This was a consideration in the McDowell and Long Creek watersheds. Both the Stewart Creek and Edwards Branch focus areas were attractive due to other restoration projects in adjacent areas, which presented an opportunity to continue improving the water quality in these areas.

Similar discussions would need to take place to select the next round of focus areas for project site selection. Topics to consider are as follows:

- Coordination with and building upon other restoration/preservation activities
- Known needs due to current growth conditions and/or impending development
- Balancing funding within the socio-political regions
- Community involvement and educational opportunities
- Mitigation potential

Once additional focus areas are selected, the same site selection process can be implemented. Stream and potential wetland sites were identified throughout the watersheds in a prior phase. The locations of these sites within the focus area will lead to the assessment of untreated areas and potential BMP locations. Field assessments would need to be conducted and the data analyzed. The effectiveness of the sites would need to be determined to remove sites from consideration that do not incrementally add much benefit for their cost. This approach will result in a capital improvement project list for each focus area.

Additional Control Assessment

Water Quality Review

As outlined in TM 2, and the Executive Summary, the project area is experiencing significant impacts from sedimentation and habitat degradation. High levels of TSS correspond with these impacts. Nutrient levels also are elevated and may affect impoundments. High metals levels, typical of urban stormwater, also have been observed. In addition, biological and habitat monitoring shows significant impairment. The conclusions regarding the impacts are based on a review of the significant amount of water quality, biological, and habitat data available within the six watersheds. The data have been collected by MCWQ, CSWS, DWQ, U.S. Geological Survey (USGS), and Charlotte-Mecklenburg Utilities (CMU). Figure ES-2 in the Executive Summary illustrates the health rating that was assigned to each watershed based on a review of the data.

Some of the overall impairment is attributable to development of the watersheds, and specifically, from the hydrological changes that result from changes in land use and the addition of impervious cover. As the landscape is urbanized and imperviousness increases, several impacts occur:

- Less rainfall can infiltrate the soils, which means that fewer pollutants are absorbed and filtered by the soil. These pollutants then run directly into streams, which negatively affects water quality.
- Less rainfall infiltrating the soils translates to less water flowing into groundwater and subsequently back into our surface waters. Therefore, during periods of minimal rain, the groundwater table is lower and the flow within our streams is lower. This scenario can threaten the amount of water available from our surface water supplies and wells during dry years.
- A greater portion of stormwater runs across the land directly into the County’s streams. This situation creates higher storm flows within the streams, which results in increased flooding, thus damaging property and threatening or even claiming lives.
- Higher storm flows within streams cause higher in-stream erosion, which increases stream sediment loads, impairs aquatic habitat, and results in reduced aquatic biodiversity.

TM 2 includes a detailed review of the watershed assessment information and impairment determination process. In addition, some further information about nutrient loading in the project area is provided below.

Nutrients

The 2002 Mecklenburg County State of the Environment Report (SOER) indicates that water quality indices in Mountain Island Lake ranged from good to excellent in 2001. The report notes that lower ratings occurred within the McDowell Creek arm of the lake due to higher nutrient loading, and these conclusions are supported by data collected by DWQ. Mountain Island Lake, a water supply source, has been classified as oligotrophic by DWQ. Elevated nutrient concentrations have been found in the McDowell Creek arm of the lake, and the McDowell Creek wastewater treatment plant (WWTP) has been assigned nutrient limits in its NPDES permit. Problematic algal blooms have not been documented in the lake (NCDENR, 1998), and according to NCDENR, there are no significant water quality problems in the lake.

The USGS, CMU and MCWQ collected hydrologic data from April 1994 to September 1997 and water quality data from April 1996 to September 1997 to characterize the lake and to support the development of a water quality model. The USGS simulated circulation and water quality processes using CE-QUAL-W2, which is a two-dimensional hydrodynamic model developed by USACE.

Data collected by Mecklenburg County indicate that Lake Wylie has the lowest water quality of the Catawba chain lakes that border on the county. The lower rating is due in large part to nutrient loading from the tributaries to the lake. The South Fork Catawba River arm of the lake has the lowest water quality with a rating of fair/good. DWQ has classified Lake Wylie as eutrophic, and a similar classification was assigned by the South Carolina Department of Health and Environmental Control (DHEC) (DHEC, 1996). Algal blooms and fish kills have been observed in embayments and tributary arms of the lake (DWQ, 1995). Nutrient loading has been linked to both point and non-point sources within the watershed. DWQ established a nutrient reduction program that focused on point sources. Non-point sources were to be addressed through voluntary efforts and prioritizing the area for cost share funds to implement BMPs (NCDENR, 1999).

South Carolina has noted increasing trends in TP, total nitrogen (TN), and turbidity in Fishing Creek Reservoir (DHEC, 1999). Because of elevated TP concentrations in the lake, South Carolina has included Fishing Creek Reservoir, Cedar Creek Reservoir, and Lake Wateree on its 303(d) list, its list to the EPA of impaired waters. DHEC currently is developing the models to support a TMDL for TP in the watershed. DHEC also has developed nutrient standards for reservoirs in South Carolina. The standards for the reservoirs above are 0.06 milligrams per liter (mg/L) TP, 40 micrograms per liter (µg/L) chlorophyll *a*, and 1.5 mg/L TN.

Water Quality Programs

The federal, state, and local governments have programs in place to protect and restore water quality. Although many programs protect water quality, this summary is confined to those that may directly address nutrient, sediment, fecal coliform and toxics loading or help to maintain in-stream flow.

Mecklenburg County Monitoring

The 2002 SOER outlines a history of the use of streams in Mecklenburg County. In the late 1960s, the *Charlotte News* ran a series of articles about declining water quality in the inner City of Charlotte in Little Sugar Creek. An assistant professor of biology at UNC–Charlotte was unable to find any fish in this portion of Little Sugar Creek. On the basis of these findings, the Mecklenburg County Board of Commissioners (Board) provided funding to begin the county's Water Quality Program. It should be noted that this occurred before the implementation of the federal Clean Water Act.

The county's water quality program has continued to grow, and as described in earlier TMs, the county collects extensive water quality data that are useful to help determine the health of the county's streams. The monitoring has detected problems that city and county staff were able to trace to specific sources and address. The SOER outlines several examples where monitoring by staff and observations by citizens were followed up and pollutant discharges were eliminated. These included leaking sewer lines, illicit discharges, and illegal dumping.

Surface Water Improvement Management Program (SWIM)

In October 1996, the Board issued a policy statement calling for all surface waters in the county to be suitable for prolonged human contact and to support a variety of aquatic life. The Board appointed a citizen advisory panel to develop a strategy to meet the policy goal statement. The panel reached consensus on a three-phased program in January 1998, and on the components of Phase I in April 1998. Phase I included the following recommendations:

- Enhance enforcement of erosion and sediment control ordinance
- Enhance enforcement of riparian buffers in water supply watersheds
- Establish riparian buffers throughout the county
- Address elevated levels of fecal coliform
- Implement county-wide modeling supported by enhanced water quality monitoring
- Improve coordination between city and county agencies
- Increase public education and awareness

The Phase I program was fully implemented in 1999. According to water quality monitoring data, fecal coliform has been reduced by 46 percent in Briar Creek, 62 percent in McAlpine Creek, 73 percent in Little Sugar Creek, and 78 percent in Sugar Creek. Sediment loads in Long, McDowell, Sugar, and McAlpine creeks have decreased, but have increased in Little Sugar Creek. More sediment data are needed to accurately identify long-term trends.

Stormwater Regulations

DWQ enforces federal NPDES stormwater regulations. The program is designed to reduce or eliminate pollutants in stormwater runoff from municipal storm sewer systems and industrial activities. The City of Charlotte was covered under the Phase I portion of the program. The Phase II permanent rules were adopted on July 10, 2003, and contain six minimum measures to help protect water quality:

- Public education program
- Public involvement program
- Program to detect and eliminate illicit discharges
- Program to address construction site runoff from areas disturbing 1 acre of land or greater (meeting the requirements of the Sedimentation Pollution Control Act described below fulfills this requirement)

- Program to address post-construction runoff
- Pollution prevention program

The rules require that high-density development (greater than 24 percent built-upon area) must control the runoff so that the first inch of runoff is treated, and structural stormwater controls must remove 85 percent of TSS. In addition, local governments are to develop a program to control sources of fecal coliform. Mecklenburg County and the communities surrounding Charlotte will be required to meet the requirements of the Phase II program. The City of Charlotte also will have to meet the Phase II requirements when its current NPDES stormwater permit is renewed.

The city and county already exceed the federal stormwater requirements, and Mecklenburg County will be implementing the Phase II program for the local governments within the county. The county will work with the local governments to identify programs to meet the Phase II requirements. This process requires coordination and communication, but should enable local governments to comply with the NPDES stormwater requirements more efficiently. It also enables the county and local governments to review the county's waters holistically and should result in a program that better protects water quality from a watershed basis.

The city and county are collaborating on a plan to guide water quality education and public involvement. This plan will include a large media campaign to educate the citizens about stormwater. The city also is developing a formal water quality strategy to guide future stormwater programs.

The city and county also are developing computer models of the watersheds. These models will be used to predict the impacts of additional growth on water quality and help develop management plans and practices to protect the county's water resources.

Total Maximum Daily Loads

Section 303(d) of the Clean Water Act requires states to identify waters that do not support their classified uses. These waters must be prioritized, and a TMDL must subsequently be developed. TMDLs are calculations that determine the maximum amount of a given pollutant that a waterbody can assimilate and still maintain its uses. As part of the TMDL, the sources of the pollutant must be identified, and the allowable amount of the pollutant must be allocated among the various sources within the watershed. There are waters on North Carolina's 303(d) list in the study area for biological impairment, turbidity impairment, and fecal coliform impairment.

DWQ, in cooperation with local governments, will perform studies to determine the sources of biological impairment. If a pollutant is causing the impairment, a TMDL will be developed. For many of the watersheds, habitat degradation due to sediment deposition, substrate instability, or other factors that may result from the hydrology changes that occur with development is one of the causes of impairment. Data presented in TM 2 indicate that habitat degradation is one of the causes for biological impairment in some waters. For waters impaired by habitat degradation, a TMDL is not required. However, strategies such as stream and riparian buffer restoration can help improve the habitat and biological rating in these streams.

A TMDL to address fecal coliform impairment throughout the study area was approved in March 2002. This TMDL was developed by Mecklenburg County in concert with DWQ. This TMDL contained recommendations to control fecal coliform loading from both point and non-point sources within the study area. Thus, this study does not explicitly address fecal coliform, although some of the recommendations may help prevent bacteria from reaching waters in the study area.

DHEC currently is developing a TMDL to address the nutrient impairment in Fishing Creek Reservoir and other reservoirs downstream on the Catawba chain. NPDES facilities in the watershed have implemented controls to reduce their phosphorus loadings. Currently, modeling is underway to determine the allowable phosphorus load and to allocate it among the various pollutant sources. In the meantime, non-point sources should maintain phosphorus loading at current levels.

Erosion and Sediment Control

The North Carolina Division of Land Resources (DLR) administers programs to control erosion and sedimentation caused by land-disturbing activities. An approved site plan is required for those sites that disturb 1 acre or more of land. Mecklenburg County enforces its own erosion and sediment control program, which contains an aggressive inspection program. Each erosion and sediment control device is supposed to be inspected at least once per week by either the developer or a county agent, and devices are also supposed to be inspected within 24 hours of a storm that generates 0.5 inches of rain within a 24-hour period. In addition, staff began inspecting single-family residence construction in 1999. According to the 2002 SOER, more than 14,000 residential sites were inspected between August 1999 and May 2001. The County's erosion control program earned an award in 2000 from the North Carolina Sedimentation Control Commission.

Huntersville Low Impact Development

The Town of Huntersville has adopted a new stormwater ordinance that establishes stormwater management requirements and controls to prevent surface water quality degradation to the extent practicable in the streams and lakes within the Town Limits and Extraterritorial Jurisdiction of Huntersville. This ordinance was written to comply with the Phase II stormwater requirements, but exceeds them by requiring that all new development employ low-impact development (LID) features to control and treat the first inch of rainfall.

The main objectives of the ordinance are noted below:

- Minimize increases in stormwater runoff from development or redevelopment in order to reduce flooding, siltation and streambank erosion, and maintain the integrity of stream channels
- Minimize increases in non-point source pollution caused by stormwater runoff from development or redevelopment that would otherwise degrade local water quality
- Minimize the total volume of surface water runoff that flows from any specific site during and following development in order to replicate pre-development hydrology to the maximum extent practicable

- Reduce stormwater runoff rates and volumes, soil erosion and non-point source pollution, to the extent practicable, through stormwater management controls (BMPs) and ensure that these management controls are properly maintained and pose no threat to public health or safety

The following performance criteria are required by the ordinance:

- All storm water treatment systems used to meet these Performance Criteria shall be designed to achieve average annual 85 percent TSS removal for the developed area of a site. Areas designated as open space that are not developed do not require storm water treatment. All sites must employ LID practices to control and treat runoff from the first inch of rainfall.

- LID practices or a combination of LID and conventional stormwater management practices shall be used to control and treat the increase in stormwater runoff volume associated with post-construction conditions as compared with pre-construction (existing) conditions for the 2-year frequency, 24-hour duration storm event in the Rural and Transitional Zoning Districts. For all other Zoning Districts, LID practices or a combination of LID and conventional stormwater management practices shall be used to control and treat the increase in stormwater runoff volume associated with post-construction conditions as compared with pre-construction (existing) conditions for the 1-year frequency, 24-hour duration storm event.

- Where any stormwater BMP employs the use of a temporary water quality storage pool as a part of its treatment system, the drawdown time shall be a minimum of 48 hours and a maximum of 120 hours.

- Peak stormwater runoff rates shall be controlled for all development above 12 percent imperviousness. The peak stormwater runoff release rates leaving the site during post-construction conditions shall be equal to or less than the pre-development peak storm water runoff release rates for the 2-year frequency, 24-hour duration storm event and 10-year frequency, 24-hour duration storm event. The emergency overflow and outlet works for any pond or wetland constructed as a storm water BMP shall be capable of safely passing a discharge with a minimum recurrence frequency of 50 years. For detention basins, the temporary storage capacity shall be restored within 72 hours. Requirements of the Dam Safety Act shall be met when applicable.

- No one BMP shall receive runoff from an area greater than 5 acres. However, the total drainage area from BMPs used in series (i.e., integrated) can exceed this 5 acre maximum.

Pollutant Loading

A water quality model was used as part of this study to evaluate the NPS and point source pollutant loadings under existing and a variety of future management scenarios. On the basis of the objectives established for this project and the availability of existing models, the BASINS modeling platform was selected for the watershed loading. Specifically, the Hydrologic Simulation Program–FORTRAN (HSPF) modeling component within BASINS was used to estimate pollutant loadings for TSS, TP, and zinc. Further information is provided in TM 3b.

McDowell Creek had already been modeled using HSPF by another consultant, and the model was not altered as part of this study (Tetra Tech, 2001). There also were existing HSPF models for Irwin/Sugar, Briar/Little Sugar, and McAlpine Creek watersheds that were used for the development of the fecal coliform TMDLs. The McAlpine Creek model included McMullen Creek; these two watersheds were not examined separately in this study. Finally, an HSPF model was developed for Long Creek as part of this study.

The loading results from the water quality models were used to create a BMP tool to assess the impacts of various improvement scenarios. The BMP tool calculations are based on the loading rates and the land uses in each catchment, as well as on established BMP efficiencies for any proposed BMPs within a catchment.

Pollutant Loading Targets

Suspended Sediment Loading Target

As outlined in TM 2, there are several stream segments on North Carolina's 303(d) list within the study area based on turbidity levels. Turbidity is an indicator of sediment impacts. Thus, at a minimum, TSS loading should not increase. Because non-point sources typically account for many of the solids and turbidity within a waterbody, solids loading from the non-point sources probably will need to decrease from existing conditions to meet the turbidity standard. In addition, sediment may be causing some habitat degradation, which in turn, leads to biological impairment.

Tetra Tech (2001) assessed the water quality in the McDowell Creek watershed and performed a literature review of sediment loading from Piedmont watersheds under varying land cover. On the basis of their literature review, they recommended a sediment loading target of approximately 0.3 ton/acre-year (600 lbs/acre-year). This amount is consistent with a target suspended sediment loading considered for the Metro North Georgia Water Management District (MNGWMD) (16-county area around Atlanta) of 700 lbs/acre-year. However, because of differences in approaches between local governments, a TSS target of 80 percent removal for new development was adopted for the MNGWMD. In addition, a restoration target of having the watersheds mimic hydrology associated with 10 percent directly connected (not total) impervious cover was adapted. This latter target was used in lieu of specific pollutant loading targets, because meeting this value would require BMPs and restoration projects that would also address pollutants.

The target of 600 lbs/acre-year is a good initial goal for the portions of the study area that are heavily developed and significantly impaired for sediment. However, many of the catchments currently have lower levels of development and have significantly lower pollutant loadings. For these areas, it seems reasonable to maintain the existing loading. When further data are available, the target could be modified.

TP Loading Target

As described above, DHEC is establishing TMDLs in Fishing Creek Reservoir and other downstream reservoirs on the Catawba chain. Sugar Creek, Little Sugar Creek, and McAlpine Creek all drain to the Catawba River upstream of Fishing Creek Reservoir.

NPDES facilities in the watersheds have implemented controls to reduce phosphorus loading. Modeling currently is underway to determine the allowable phosphorus load and to allocate it among the various pollutant sources. Guidance issued by EPA indicates that until TMDLs are developed, pollutant loads should not increase.

Although Mountain Island Lake and Lake Wylie (lakes receiving water from McDowell Creek and Long Creek, respectively) are not listed as impaired, MCWQ and DWQ have concerns about the nutrient loading in them. The McDowell Creek WWTP has implemented nutrient controls to address enrichment in the McDowell Creek arm of Mountain Island Lake, one of Charlotte's drinking water supply reservoirs. DWQ also has established nutrient loading targets in Lake Wylie. Although the Lake Wylie strategy focused on point source loading, NPSs were to voluntarily reduce their loads, and the watershed is a priority area for agricultural cost share money.

Tetra Tech (2001) performed a literature review of total phosphorus loading to develop target criteria. On the basis of this literature review, they recommended that a concentration of 0.04 mg/L TP be maintained in-stream. South Carolina has developed nutrient criteria for its reservoirs, including piedmont reservoirs achieving a concentration of 0.06 mg/L. A target of 0.04 mg/L was used in TM 3b.

To convert the TP concentration targets above to loading targets, the existing in-stream TP concentration and existing areal TP loads were used. The ratio of these two numbers in a given watershed were used to determine what the areal load should be to achieve the target in-stream concentration:

> (existing in-stream concentration)/(existing areal TP load) = (target in-stream concentration)/target areal TP load

For the McAlpine Creek, McDowell Creek, Irwin/Sugar Creek, and Briar/Little Sugar Creek watersheds, the point source concentrations exceeded the predicted concentrations at the watershed outlet. As illustrated in TM 3b, the point sources make up the majority of the phosphorus load in these watersheds. For Long Creek, where there are no point source inputs, the target loading rate was 0.3 lb/ac-year when an in-stream concentration target of 0.04 mg/L was used. When a target concentration of 0.06 mg/L was used, the loading target increased to 0.5 lb/acre-year.

These targets may be difficult to meet. The Research Triangle Institute conducted a literature search of export coefficients that have been used in modeling analyses in North Carolina (Dodd and McMahon, 1992). On the basis of that literature review, median export coefficients for various land uses were as follows:

- Forest/Wetland–0.12 lb/ac-yr
- Agriculture–0.88 lb/ac-yr
- Developed Land–0.95 lb/ac-yr
- Atmospheric Deposition–0.58 lb/ac-yr

In the watersheds that have higher levels of imperviousness, it may be difficult to meet a phosphorus loading target of 0.5 lb/ac-yr, because the amount of phosphorus loading from atmospheric deposition may exceed that load and be transported directly from impervious surfaces to nearby streams.

Zinc Loading Target

To date, there is no apparent zinc impairment in any of the watersheds. The modeling results outlined in TM 3b, indicate that under current loads, the action level of 50 µg/L is met at all times except for downstream of the WWTPs. However, the North Carolina water quality requirement for zinc is based on an action level, because toxicity impacts from zinc are heavily influenced by the form of zinc (total recoverable or dissolved) in water, as well as the presence of other materials in water that affect the toxicity of zinc and other metals. It seems reasonable to allow the NPDES permitting processes to address any requirements for zinc at the WWTPs and to maintain existing loadings from the watersheds.

Pollutant Loading Under Existing Conditions

Existing land use was used in the HSPF models to estimate existing pollutant loads. These loads were then incorporated into the BMP tool to assess various scenarios. Two scenarios were run under existing land use conditions:

- Scenario 1: Existing land use
- Scenario 2: Existing land use with projects identified for each of the focus areas

The results of the analyses examining the effectiveness of the projects in the focus areas were presented previously and were used to recommend which projects to implement in each of the focus areas. The predicted results are included in Table 5 to show the effect of these measures at the watershed scale.

TABLE 5
Predicted Pollutant Loads within Each Watershed under Existing Conditions
Charlotte Area Local Watershed Plan

Scenario[1]	TSS (lbs/ac-yr)	TP (lbs/ac-yr)	Zn (lbs/ac-yr)
McDowell Creek			
Scenario 1	860	0.50	0.077
Scenario 2	860	0.50	0.077
Long Creek			
Scenario 1	577	0.55	0.052
Scenario 2	507	0.50	0.051
Irwin/Sugar Creek			
Scenario 1	779	0.70	0.081
Scenario 2	752	0.69	0.081
Briar/Little Sugar Creek			
Scenario 1	846	0.86	0.129
Scenario 2	838	0.86	0.128

TABLE 5
Predicted Pollutant Loads within Each Watershed under Existing Conditions
Charlotte Area Local Watershed Plan

Scenario[1]	TSS (lbs/ac-yr)	TP (lbs/ac-yr)	Zn (lbs/ac-yr)
McAlpine Creek			
Scenario 1	498	0.45	0.072
Scenario 2	431	0.42	0.066

Notes:
[1] Scenario 1 = Existing Land Use
Scenario 2 = Existing land use with projects identified for each focus area

Long Creek and McAlpine Creek currently exhibit TSS loads that are less than the target of 600 lbs/acre-year. Existing land use data indicate that Long Creek has one of the lower levels of development within the study area (14 percent impervious), and McAlpine Creek has moderate development (24 percent impervious) compared with other watersheds. However, as noted in prior documentation, the land use data do not accurately reflect the activities in rapidly developing watersheds such as McDowell Creek and Long Creek. Both the Long Creek and the McAlpine Creek watersheds are listed as impaired on the North Carolina 303(d) list for turbidity. Thus, TSS loading within these watersheds should be held at existing levels and reduced if possible.

The results, shown at the watershed scale, indicate that there is similar pollutant loading between the two scenarios. The predicted results at the focus area scale are summarized in TM 4, as well as in the Introduction of this document. The results illustrated that the focus area projects are effective on the smaller catchment level. Identifying and implementing projects in all 30 focus areas probably would have a bigger impact on the watershed scale results.

Pollutant Loading Under Various Future Management Scenarios

The BMP tool was run under a variety of management scenarios based on future land use. The future land use was estimated in a GIS coverage by the Charlotte-Mecklenburg Planning Department based on combined area plans. Area plans serve as policy guides and address how parts of the community should be maintained and/or changed in the future. Each plan makes recommendations on land use, zoning, transportation, and other issues to realize the vision of the area.

A comparison was made between the existing land use and the future land use, which represents 2015 estimates. The land use category in each catchment was determined for both existing and future conditions. If there was an increase in area for a particular land use category from the 1998 land cover and the 2015 estimate, this area was assumed to be new development and/or redevelopment. Typically, residential, commercial, and industrial areas were increasing while woods and brush were decreasing. However, in some instances, there was a decrease in some land use categories. These areas were assumed to have zero new development. The representation of future conditions/new development were input to the BMP tool under five potential management scenarios:

- Scenario 3: No controls on pollutant loads
- Scenario 4: Projects identified for each of the focus areas
- Scenario 5: Projects identified for each of the focus area, along with controls on new development. The controls on new development assume 85 percent TSS removal, 50 percent TP removal, and 50 percent zinc removal. The removal rate for TSS is based on NPDES Phase II Stormwater requirements, and the phosphorus removal is based on the TSS removal, because much of the TP is associated with suspended material.
- Scenario 6: Projects identified for each of the focus areas, along with controls on new development and stream restoration occurring within the watersheds. It was assumed that 25 percent of the stream miles are restored. For rapidly developing watersheds, Long Creek and McDowell Creek, the following stream bank restoration reduction efficiencies were used: TSS = 35 percent, TP = 18 percent, and Zn = zero percent. The remaining watersheds were assumed to be built out and the stream bank restoration reduction efficiencies were assumed to be at TSS = 50 percent, TP = 25 percent, Zn = zero percent.
- Scenario 7: BMPs identified for each of the focus areas within this study are applied, along with controls on new development, stream restoration (25 percent), and retrofits of existing development. The individual catchments were assessed to determine if they met the loading targets. If not, the new development control efficiency was applied to determine the amount of area that would need to be treated to reach the target. This area was then assumed to treat at the control development efficiency to determine the final load.

Table 6 summarizes the BMP tool results.

TABLE 6
Pollutant Loading within each Watershed Under Various Future Management Scenarios
Charlotte Area Local Watershed Plan

Scenario[1]	TSS (lbs/ac-yr)	TP (lbs/ac-yr)	Zn (lbs/ac-yr)
McDowell Creek			
Scenario 3	991	0.59	0.094
Scenario 4	991	0.59	0.094
Scenario 5	320	0.35	0.056
Scenario 6	289	0.34	0.056
Scenario 7	289	0.34	0.056
Long Creek			
Scenario 3	939	0.93	0.103
Scenario 4	864	0.88	0.100
Scenario 5	210	0.49	0.057
Scenario 6	183	0.47	0.057

TABLE 6
Pollutant Loading within each Watershed Under Various Future Management Scenarios
Charlotte Area Local Watershed Plan

Scenario[1]	TSS (lbs/ac-yr)	TP (lbs/ac-yr)	Zn (lbs/ac-yr)
Scenario 7	183	0.47	0.057
Irwin/Sugar Creek			
Scenario 3	1104	0.94	0.127
Scenario 4	1077	0.93	0.127
Scenario 5	442	0.62	0.082
Scenario 6	394	0.60	0.082
Scenario 7	387	0.60	0.076
Briar/Little Sugar Creek			
Scenario 3	902	0.93	0.138
Scenario 4	894	0.92	0.137
Scenario 5	609	0.76	0.111
Scenario 6	569	0.74	0.111
Scenario 7	556	0.73	0.097
McAlpine Creek			
Scenario 3	571	0.59	0.096
Scenario 4	503	0.56	0.090
Scenario 5	267	0.42	0.067
Scenario 6	242	0.40	0.067
Scenario 7	242	0.40	0.067

Notes:
[1] Scenario 3 = Future conditions, not controls or projects
Scenario 4 = Future conditions with focus area projects
Scenario 5 = Scenario 4, plus with post-construction runoff control for new/redevelopment
Scenario 6 = Scenario 5, plus stream restoration
Scenario 7 = Scenario 6, plus additional retrofit

The results indicate that in some of the watersheds, future land use results in significant increases in pollutant loading when compared to the existing pollutant loads. In Long Creek, the pollutant loading for TSS, TP, and zinc almost doubles when compared to current conditions. In Irwin/Sugar Creek, pollutant loads increase by approximately 50 percent when compared to current loads, and increases of approximately 20 percent are seen in McDowell and McAlpine Creeks.

Minor reductions on future loads are seen when the focus area projects are added and reviewed on a watershed scale. When the focus area projects are reviewed at the catchment level, significant reductions are noted. If projects were identified and implemented in all 30 focus areas, more significant reductions would be noted between Scenarios 3 and 4.

When new development controls are implemented (Scenario 5), significant reductions occur with the existing loads. All land uses including forests generate some sediment runoff. If existing land uses that generate higher levels of sediment runoff are developed, the sediment runoff may be reduced, because new development controls assumed that 85 percent of TSS is removed based on NPDES Phase II requirements. It should be noted that the removal efficiencies from new development controls are optimistic, because some of the new development between the existing and future scenarios has and will occur before these requirements are implemented. In addition, any low-density new development will not need to implement post-construction runoff controls. Some phosphorus and zinc also will be removed from implementing the new development practices.

Further reductions are noted when stream restoration, beyond what is recommended in the focus areas, is included (Scenario 6). The results presented assume that 25 percent of the streams are restored. This percentage is conservative. If more streams are restored, further reductions in TSS are noted. For example, in Long Creek, the loading numbers shown in Table 7 are predicted when 25, 50, 75, and 100 percent of the streams are restored.

TABLE 7
Predicted Future Pollutant Loads in Long Creek with Focus Area Projects, New Development Controls, and Various Levels of Stream Restoration
Charlotte Area Local Watershed Plan

Long Creek–Percent Streams Restored	TSS (lbs/ac-yr)	TP (lbs/ac-yr)	Zn (lbs/ac-yr)
0 percent streams restored	210	0.49	0.057
25 percent streams restored	183	0.47	0.057
50 percent streams restored	154	0.46	0.057
75 percent streams restored	127	0.45	0.057
100 percent streams restored	99	0.43	0.057

The watershed itself may meet the target as noted in Table 6; however, reductions may be noted between Scenario 6 and Scenario 7 if a single catchment is above the target. Although targets were met in all watersheds for TSS, additional reductions are shown in the Irwin/Sugar Creek and Briar/Little Sugar Creek watersheds due to some individual catchments.

The modeling analyses indicate that achieving a TSS loading target less than 600 lbs/acre-year is achievable in each watershed. For all watersheds, implementing the focus area projects, along with including 85 percent TSS removal for new development, achieves the goal. For zinc, maintaining current watershed load can be achieved by implementing the focus area projects and requiring controls on new development.

For Total phosphorus, achieving a non-point load between 0.4 and 0.5 lb/acre-year is not achievable in all watersheds. It is achieved in the McDowell Creek, Long Creek, and McAlpine Creek watersheds, but it is not achieved in the Irwin/Sugar Creek and Briar/Little Sugar Creek watersheds. In all watersheds, existing load can be maintained.

Recommendations

By establishing loading targets for the various pollutants, management recommendations based on the modeling scenarios can be made. Recommendations are outlined by pollutant type below.

Total Suspended Solids

The Phase II NPDES stormwater rules will apply post-construction performance requirements to new development throughout the watersheds. Even though the City of Charlotte is a Phase I community, it is known that these new requirements will be added to its NPDES permits when they are renewed. These rules require 85 percent TSS removal from BMPs that serve the new development. Future modeling Scenario 5 assumed 85 percent reduction in TSS from new/re-development (per the new rule), along with the implementation of the projects identified for the focus areas. For each modeled watershed, future TSS loading is lower than existing TSS loading, and future loading meets the TSS loading target identified above. Thus, implementing Scenario 5 should help address the impairment by sediment. The McDowell Creek watershed shows the greatest reduction in TSS, with future loads under this scenario being approximately 37 percent of current loads. Little Sugar Creek showed the least reduction, with future loads being approximately 72 percent of current loads.

It should be noted that this analysis may present an overly optimistic view of the opportunity to improve water quality and to reduce sediment impacts through the implementation of post-construction runoff controls (Scenarios 5 through 7) for several reasons. First, the existing land use coverage is based on 1998 data; thus, significant additional development has already occurred in several of the watersheds. Second, the analysis of which parcels would require post-construction runoff controls was based on a comparison of the future versus existing coverages. If a parcel land use changed between these coverages, new development controls were applied. This approach may actually over-estimate parcels that will receive these future controls, depending on how the controls are implemented and the actual redevelopment and land use changes that occur.

Finally, both stormwater peak flow and volume control are of critical importance in protecting stream channels from erosion. The Phase II stormwater regulations require the treatment of the first 1 inch of rainfall, which in effect help control increases in pollution runoff. However, control of the total volume of runoff and peak flow are not required, both of which help mimic pre-development hydrological conditions and maintain stream channel stability. Efforts to manage stormwater to protect and stabilize stream channels also will be important in managing sediment impacts in streams, as noted in the recommendations regarding flow below. Stream restoration further reduces TSS loads and also will help meet other goals. As illustrated in Table 7, in Long Creek, TSS loads are reduced 13 percent when 25 percent of the streams are restored, 27 percent when 50 percent of the streams are restored, and 40 percent when 75 percent of the streams are restored. In addition, stream restoration helps improve habitat and stream stability.

The local governments should implement the post-construction runoff controls (Phase II requirements) for TSS as soon as possible. The sooner these requirements are implemented, the more effective they will be in reducing sediment loads. This is particularly important because the analysis for Scenario 5, although probably overly optimistic, indicates that these controls can make a significant difference in whether the sediment targets are achieved in these watersheds. The longer the time frame before these controls are implemented, the less likely it is that these controls will result in a significant reduction in future loading. In addition, the local governments should continue their efforts to minimize sediment impacts to streams through their erosion and sediment control programs. Monitoring in the impaired stream segments should continue to determine whether water quality is improving.

Total Phosphorus

The modeling analyses outlined in TM 3b indicate that point sources contribute the bulk of the phosphorus in the Irwin/Sugar Creek, Briar/Little Sugar Creek, and McAlpine Creek watersheds. The point source contribution of TP in these watersheds is in excess of 90 percent. CMU has agreed to reduce phosphorus levels in its WWTPs by 70 percent over the next 5 years.

Because the data indicate that nutrient loading is high in the watersheds, it is important to address TP. However, since modeling indicates that point sources contribute the bulk of the TP , an overly aggressive non-point source program to reduce nutrients may not be needed at this time. In addition, BMPs and restoration projects targeted for suspended sediment will significantly reduce TP. The loading target range of 0.3 to 0.5 lb/acre-year were based on meeting concentration targets set in other watersheds in North Carolina and in South Carolina piedmont reservoirs and, according to the modeling results, are not achievable throughout the project area. However, the target concentrations were converted to a loading target in a simplistic manner that included data from only one of the project watersheds. Thus, it is recommended that the NPS phosphorus control is based on NPDES Phase II requirements, along with the point source reductions that CMU has agreed to meet.

To avoid further nutrient problems and to meet EPA's recommendations for impaired waters, current phosphorus loading should be maintained. Continued monitoring of phosphorus and its impacts on in-stream water quality should occur. If nutrient problems continue after the point source controls are implemented or reductions are needed, based on the TMDL being developed in South Carolina, then the NPS loading target can be modified.

At a minimum, the management strategies evaluated in Scenario 5 meet the goal of maintaining the current phosphorus load in each of the watersheds. Scenario 5 assumes that the BMPs identified for each focus area are implemented and that new development BMPs remove 50 percent of the phosphorus. Again, this assumption is based on the 85 percent TSS removal and the amount of TP generally associated with TSS in Piedmont watersheds. The sooner the local governments can implement the Phase II requirements, the more effective they will be at reducing phosphorus loads, particularly in rapidly developing watersheds.

Zinc

The local governments should implement the NPDES Phase II requirements for TSS and the recommendations for TP outlined above. If management practices are installed to meet the phosphorus and TSS recommendations, it is likely that much of the zinc generated from new development will be removed. Monitoring of the watersheds should continue to ensure that those practices are adequate for addressing zinc and other heavy metals.

Flow

Modeling was not performed to determine the impacts of growth on hydrology and the resulting impacts on water quality. However, studies across the nation indicate that changes in hydrology that occur with development are one of the main factors in watershed impairment. Available monitoring data and the field work that has been performed in the study area show low biological scores and low habitat scores. Changed hydrology is a major causal factor for these impacts. Field crews noted eroded stream banks and incised channels that are indicative of the impacts of hydrology on the area streams.

Streams are significantly affected by changed hydrology as a result of increasing imperviousness from urban development. Streams experience increased peak flows and runoff volumes from storms and significantly less interflow-baseflow to streams between events. This change in peak flow and runoff volume results in stream channel erosion, channel incision, increased turbidity, decreased habitat, and decreased biological health. Where possible, the pre-development stormwater runoff volume should be maintained.

Design techniques that encourage stormwater infiltration and evaporation and minimize the runoff should be used to the maximum extent practical. These techniques include minimizing the amount of impervious surfaces within a development, disconnecting rooftop runoff from the stormwater conveyance system, using vegetated channels to convey runoff where practical, and using BMPs such as bioretention to encourage infiltration. These practices help mimic the natural hydrology of the site and minimize the impacts of urbanization on the environment.

Ordinances such as the one implemented by Huntersville should be reviewed by the local governments within the project area to determine if there are elements of them that can meet their unique needs. Where practical, local governments should begin to review options to reduce stormwater runoff volume from new development. Key features of the Huntersville ordinance, in addition to the 85 percent TSS removal required for post-construction runoff control, that should be strongly considered by local governments include:

- A design-storm or other runoff volume requirement to minimize the increase in stormwater volume with new or an increase in development. Huntersville requires the control of the increased volume from either a 2-year, 24-hour storm or a 1-year, 24-hour depending on whether a parcel is in a Rural or Transitional Zoning District or outside of one of these areas, respectively.

- A retention requirement for maintaining post-construction peak flow rates to pre-development rates for a specified design storm. This is already a requirement for commercial/industrial development within the City of Charlotte and Mecklenburg County. Huntersville requires control of peak flows for all development exceeding 12 percent imperviousness based on both a 2-year frequency, 24-hour and 10-year frequency, 24-hour duration storm event.

- Reliability considerations to BMP design so that successful stormwater control is not contingent on only one BMP. Huntersville limits a BMP drainage area to 5 acres and encourages BMPs in series.

Monitoring Assessment

The purpose of the monitoring assessment was to determine if additional monitoring is needed to assess the effectiveness of the proposed watershed management plan. The monitoring program established should help the WRP, City of Charlotte, and Mecklenburg County determine if implementation of the watershed plan is improving water quality within the study area.

Summary of Existing Data Collection

As described below, there is a wealth of data being collected within the project area to assess water quality conditions. More information regarding the available data is included in TM 2.

Water Quality Data

Water quality data can be compared to North Carolina's water quality standards to help determine potential causes of water quality degradation. MCWQ staff collect ambient and/or stormwater quality data quarterly at 47 stations throughout the county, including 30 in the study area. DWQ also collects ambient water quality data at five locations in the study area. These locations generally correspond to MCWQ sites; however, data are collected on a monthly basis. CMU collects data in the McDowell Creek and Irwin/Sugar Creek watersheds as part of its NPDES permit requirements. Finally, the USGS collects continuous data on field parameters at four sites within the Briar/Little Sugar Creek and Irwin/Sugar Creek watersheds and collects sediment data in McDowell Creek. The MCWQ and the DWQ sampling sites are shown in Figure 16**.**

Biological Data

MCWQ and DWQ collect benthic macroinvertebrate and fish data to characterize the biological condition of streams in the county. In many ways, these biological data are the most reliable data with which to assess water quality conditions. The desired condition of the biota in streams and lake systems is a diverse and balanced community. These organisms live in the water for all or large portions of their life cycles and thus can be sensitive indicators to water quality degradation, and can even help to identify the type of pollution affecting the community. DWQ relies heavily on biological data in the assessments conducted as part of the 305(b) assessment and 303(d) listing processes.

MCWQ follows DWQ methodology in quantifying data using the North Carolina Index of Biotic Integrity (NCIBI) for fish and the benthic macroinvertebrate metrics of Ephemeroptera, Plecoptera, and Trichoptera (EPT) Taxa Richness and North Carolina Biotic Index. MCWQ has 27 benthos and 11 fish sites and DWQ has 3 benthos and 3 fish sites in the project watersheds, as shown in Figure 17.

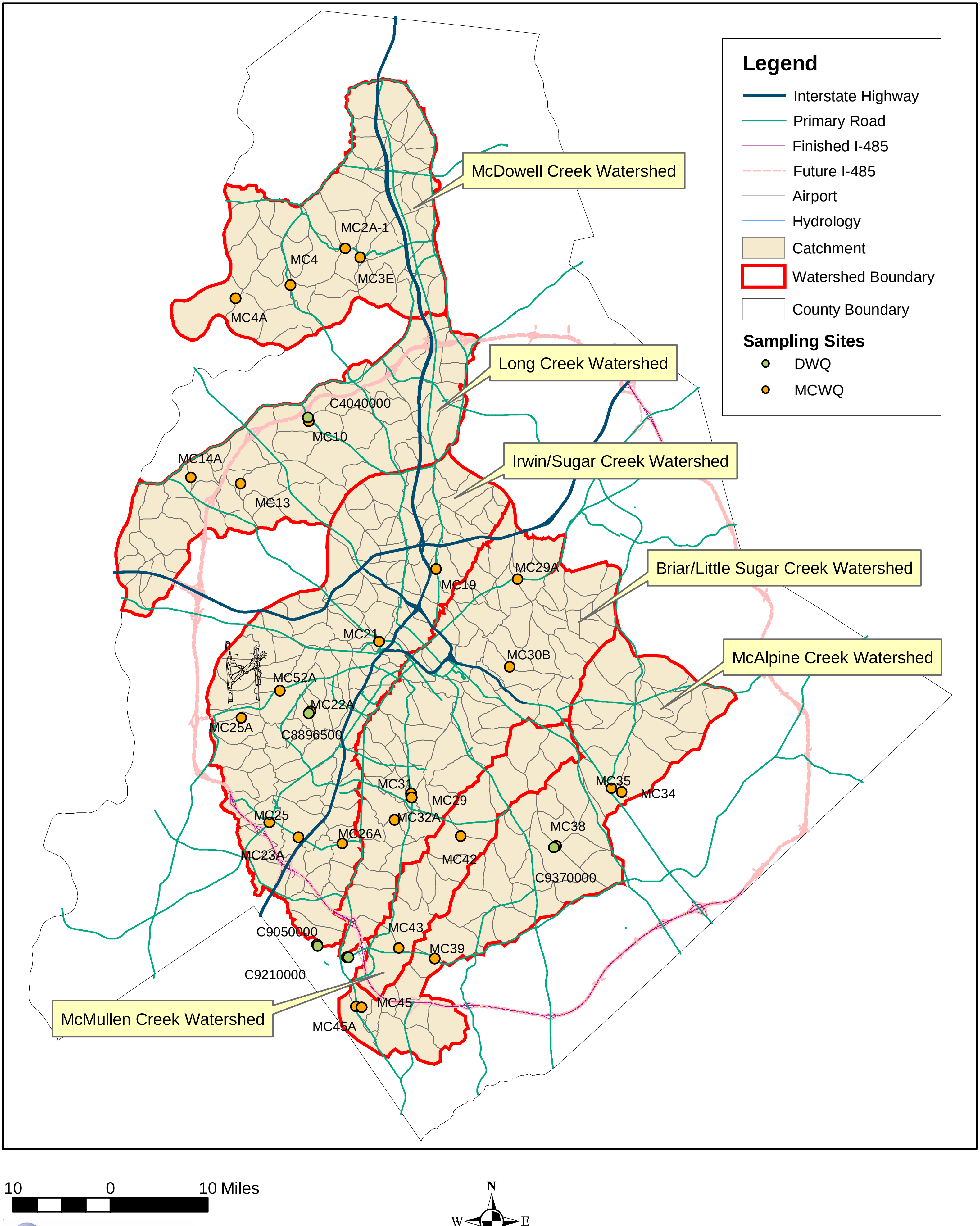

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Figure 16
MCWQ and DWQ Water Quality Sampling Sites

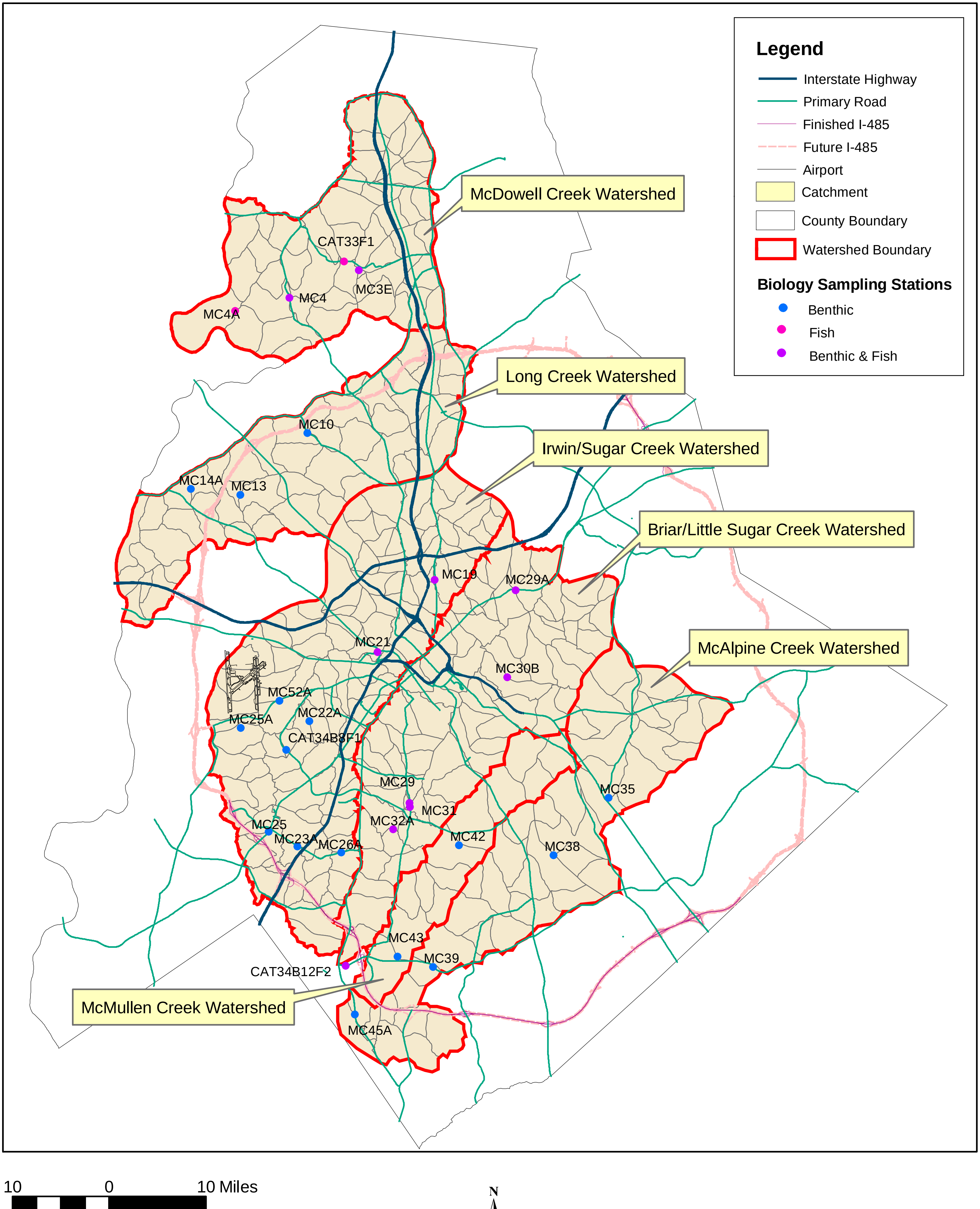

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Figure 17
MCWQ and DWQ Biology Sampling Stations

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Habitat Data

The Mecklenburg Habitat Assessment Protocol (MHAP) was developed by CH2M HILL for use in Mecklenburg County and the North Carolina Piedmont and is a modified version of EPA's Rapid Bioassessment Protocol (RBP) (CH2M HILL, 2001). The County desired a quantitative measure of habitat conditions so that it could begin to assess where biological communities were being affected by pollution or where they were limited principally by habitat conditions available in the stream. The county has collected habitat scores for each reach where biological sampling is conducted. During the development of the protocol, habitat assessments were performed in the McMullen Creek watershed. In addition, habitat assessment data have been collected at 129 sites (generally stream reaches of 100 feet or more) within the city limits, in conjunction with a stream restoration site selection project for CSWS. Figure 18 shows the locations where habitat information was available for the project watersheds.

Flow Data

Flow data are important to collect, because they can be used with water quality data to assess pollutant loads within a watershed. The USGS maintains 27 flow gages throughout the county. In addition, the USGS maintains a network of 60 computer-tracked rain gages throughout the county.

Monitoring Recommendations

Overall Project Area

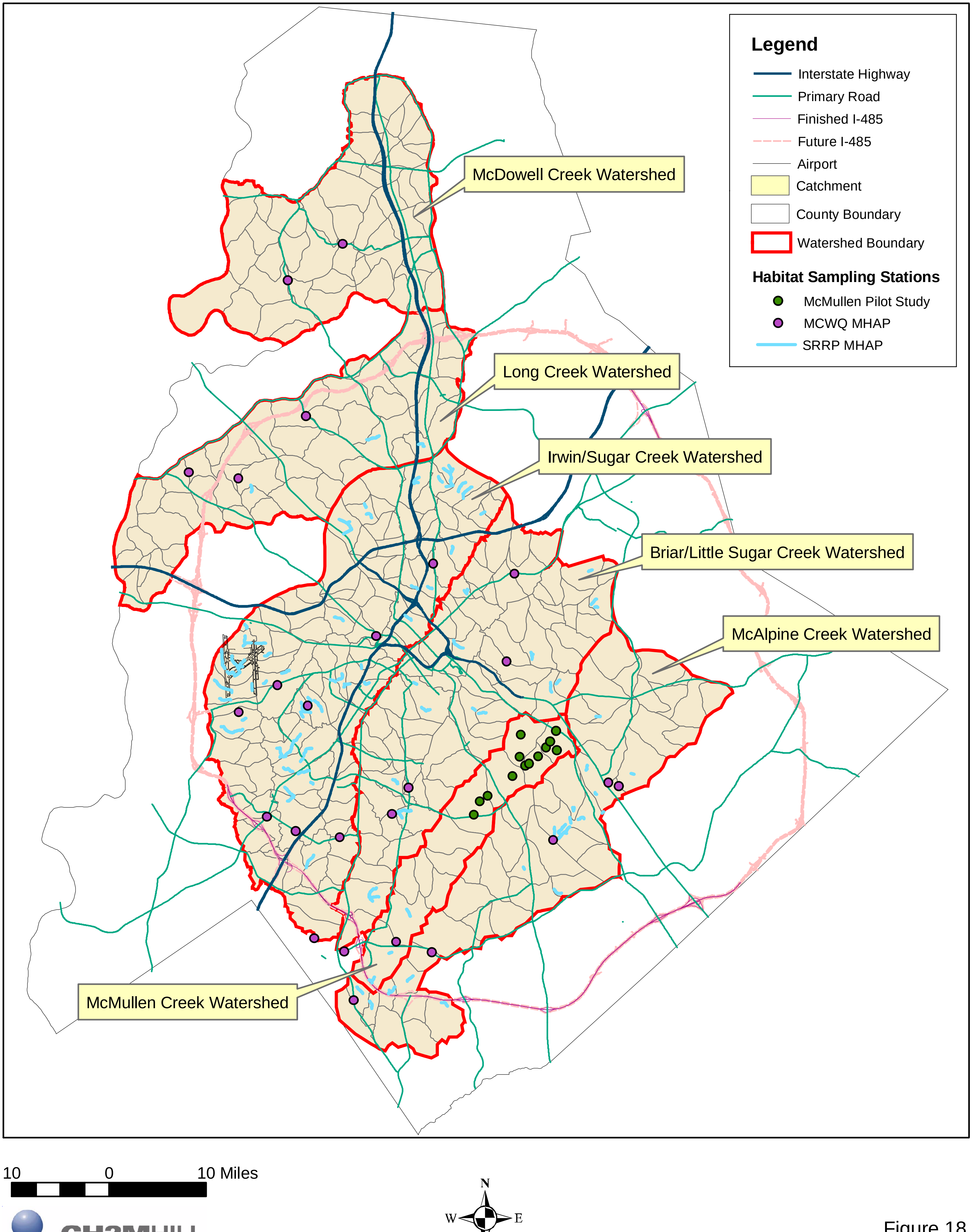
As briefly described above, a significant amount of water resources data are collected within the study area. In general, there is good coverage of the streams, and a wide variety of water resources data are available. These data enable the overall water quality within the study area to be examined. Thus, no changes are recommended for monitoring locations and frequency in the overall project area.

Focus Areas, BMPs, and Restoration Projects

Additional monitoring will be needed to assess the effectiveness of the projects that are implemented in the focus areas and for other BMPs and restoration projects that may be implemented throughout the county. If a mitigation credit program is proposed, it will be important to measure the success of the BMPs and restoration projects. Success must be shown by improvements in the natural function of the watershed. To address this aspect, water quality monitoring will be needed to evaluate the effectiveness of the BMPs. Biological monitoring near catchment outlets should be performed. The county may wish to consider additional biological metrics as part of this monitoring, as described below. For stream restoration sites, metrics that examine bank erosion should be included.

Water Quality Monitoring

Water quality monitoring should occur in focus area watersheds to gain insight into the impacts of the project activities on the overall water quality condition of the watershed. In addition, monitoring upstream and downstream of specific BMPs may be performed to determine the effectiveness of a given BMP on water quality.



CH2MHILL

Figure 18
Habitat Sampling Stations

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Biological Monitoring

The BMP focus areas are in small catchments. In small watersheds, the EPT taxa richness and Biotic Index may not adequately characterize water quality. This may also be true of using only the NCIBI for fish community scores. For this reason, the assessment of biological conditions should be evaluated using a composite score from other metrics, as outlined in Barbour et. al (1999) and the Georgia Department of Natural Resources (2002). These scores are then compared to a reference station of similar watershed size and stream order.

In Mecklenburg County, there are few watersheds that may be used as reference stations. Gar Creek typically has fairly good water quality in the county, but it is a larger watershed and can only be used as a reference station for larger watersheds. Reedy Creek is a smaller watershed in the Yadkin-Pee Dee portion of the county that has been proposed as a reference site for Edwards Branch. The county and DWQ may be aware of other streams near the study area that could be used as a reference site. For the Edwards Branch project, six benthic metrics have been proposed based on Barbour (1999). Benthic monitoring was perform to establish baseline conditions and is planned annually for 5 years after construction is completed. Habitat monitoring is being done in concert with the biological monitoring.

BMP Sites

Monitoring should be performed to assess the effectiveness of specific BMPs, and mitigation credit will actually be contingent on monitoring of the facility. For example, for stream restoration projects, monitoring that complies with the April *2003 Stream Mitigation Guidelines* (USACE et al., 2003) should be performed. For mitigation trading, a program similar to that being completed for Edwards Branch should be considered. This includes cross section surveys, pebble counts, and longitudinal profiles during construction and annually for 5 years following construction. Other BMPs should be inspected periodically to ensure that they are working as planned. In addition to monitoring, maintenance will be required as part of the Phase I and Phase II NPDES programs. If projects are to be implemented for mitigation credit purposes, maintenance will be required as a condition of receiving credit.

Summary

Significant water resources data are available within the study area that are being collected by Mecklenburg County, CMU, DWQ, and USGS. The parameter coverage and site coverage will enable the county, City of Charlotte, and the state agencies to evaluate water quality conditions within the study area. Additional monitoring will be needed in the focus areas to establish mitigation credits and to determine how the focus area BMPs are working. Finally, using only two biological metrics may not be adequate to evaluate water quality in smaller catchment areas. Thus, the city and county should consider expanding their biological metrics and comparing the metrics to a nearby reference site for small watersheds.

References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish.* Second Edition. US EPA 841-B-99-002. Washington, D.C.

CH2M HILL. 2001. Mecklenburg Habitat Assessment Protocol (MHAP). Final Report.

Georgia Department of Natural Resources. 2002. *Draft SOP: Standard Operating Procedures - Freshwater Macroinvertebrate Biological Assessment.* Water Protection Branch. Atlanta, Georgia. September 2002.

Tetra Tech, Inc. 2001. *Baseline Assessment Report for McDowell Creek, Mecklenburg County, North Carolina.* Prepared for Mecklenburg County Department of Environmental Protection.

U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, North Carolina Wildlife Resources Commission, North Carolina Division of Water Quality. 2003. *Stream Mitigation Guidelines.*